D8.11 RISKS, SYNERGIES AND EDUCATION

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Executive summary

Digital DIY (DiDIY) is the set of activities and mindsets made possible by digitally-enabled personal manufacturing technologies and tools. This first part of this document describes the main, high-level risks and opportunities that a very large adoption of DiDIY mindsets, together with access to DiDIY technologies, tool and services that is easy and really affordable to the great majority of citizens, would bring to European society. The first part also describes the main characteristics of the synergies that should happen, among the several stakeholders, to deal with those situations. The second part of the document provides a few Open Educational Resources (OER), together with guidelines to build new ones, which are already available to face the risks, and take advantage of the opportunities, that are described in the first part.

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Table of Contents

Disclaimer....2
Executive summary....2
1. Introduction....4
2. DiDIY-related risks (and opportunities)....6
2.1 Definitions: *DiDIY* scenarios, risks types and stakeholders....6
2.2 Safety, privacy and security....7
2.2.1 General issues....7
2.2.2 Privacy and identity theft....8
2.2.3 Safety, health and ethics....9
2.2.4 DiDIY and gun control....10
2.2.5 Summary of risks and concerns....13
2.3 Social divides....14
2.4 Education and lifelong learning....15
2.5 Creativity and innovation....16
2.6 Environmental footprints and consumer rights....19
2.7 Healthcare....21
2.8 Workplace and job market....23
2.9 Economic growth....24
2.10 Active citizenship, self governance....25
2.11 Summary of risks and general challenges....26
2.11.1 Unnecessary complexity....26
2.11.2 Existing business and innovation models....26
2.11.3 Separation between (mass) producers and customers....27
2.11.4 Rigidity, and scope, of laws and regulations....27
2.11.5 Ethic values and safety....27
2.11.6 Personal responsibility....28
3. DiDIY synergies....29
3.1 Main stakeholders....29
3.2 Basic *DiDIY* knowledge....29
3.3 Access to *DiDIY*....30
3.4 Rule making....31
3.5 Synergy examples....32
3.6 Towards the final guidelines: the *DiDIY* patterns wiki....33
4. DiDIY Open Educational Resources....34
4.1 DiDIY OER guidelines....34

1. Introduction

The mission of the DiDIY Project is to study the nature and long term implications for the European society of the Digital DIY (DiDIY) phenomenon. The results of such a mission shall include, among other things, some "guidelines, for EU educators and policy makers, about how to deal with DiDIY and maximize its positive impacts on society"[1]. This deliverable is an intermediate step towards those guidelines, which synthesizes:

- some general, high-level risks connected either to DiDIY becoming much more popular than today, especially if not properly regulated and supported, or to the opposite situation, the risks connected to DiDIY not being adopted enough, for whatever reason, in certain cases;
- the main goals and scopes of the synergies, among private and public stakeholders, that should be adopted or supported by laws and regulations, in order to minimize the above risks.

This deliverable has, as foundation and high-level background for its content, D6.2, "Ethical impact for regulation". While some topics, e.g., gun control, are discussed in both deliverables, what is different is the approach and the purpose. D6.2 focuses, among other things, on: general ethical analysis; the intrinsic characteristics of DiDIY activities and mindsets; the characteristics, rationale and limits of the current Intellectual Property system; the bases of other legal frameworks of contemporary society. This deliverable, instead, complements D6.2 and, in a sense, it starts where D6.2 ends. This deliverable in fact covers, at a more practical and sometimes more technical level, both the risks and the opportunities of DiDIY practised by society.

Section 2 begins with an explanation of what kinds of DiDIY adoptions, actions, individual roles, and access opportunities to the related practises, are considered as bases for all the hypotheses and scenarios that follow. The high-level risks that we consider are highly inter-dependent, hard to separate or to arrange in one definitive order, or structure. In section 2, we *attempt* to group them going from the individual to the whole society. We start from primary individual rights (safety first, then privacy, equal opportunities, education, etc) and end with larger issues, like the state of the environment or economic growth. We also try to highlight the cases in which DiDIY does not create new problems, but just intensifies ones that *already* existed before DiDIY appeared as an important social phenomenon. One of such problems is the reduction in manufacturing jobs in Europe due to globalization and automation. In the same spirit, we point out cases in which DiDIY may contribute to *solve* the same, pre-existing problems, even if at first sight it may seem that it makes them worse.

Section 3 is about synergies. Just like the risks and opportunities that DiDIY creates or intensifies are highly interdependent, so are the stakeholders that must act together, more than it has happened so far, in order to minimize the first and take advantage of the second. We summarize which kind of synergies should happen, and where, i.e., at the local or national/European level.

One thing that recurs throughout the whole document is how much of the long term positive impact of DiDIY depends on education to what we call *basic DiDIY knowledge* at all levels, from common citizens to lawmakers. After explaining why this is the case in sections 2 and 3, and in order to facilitate this education process, in the last section we provide some DiDIY Open Educational Resources, together with guidelines for producing and using more resources of the same type.

1 Source: http://www.didiy.eu/introduction.

The references to many sources quoted in this document are not direct links to the actual sources, but to posts and pages of the Project website (http://www.didiy.eu) where the same sources are linked, commented, and explained in the general perspective of the DiDIY research, more in detail than it would have been possible here.

2. DiDIY-related risks (and opportunities)

2.1 Definitions: DiDIY scenarios, risks types and stakeholders

Before describing some issues, or areas, and the risks that adoption of DiDIY (or lack thereof) would brings in those areas, it is appropriate to better define a few key elements.

In 2016, DiDIY activities and attitudes are much more common, and much more popular, than they were even five or ten years before. Nevertheless, the people who *personally* practice DiDIY or directly benefit from it still are a *tiny minority*, albeit an ever growing one, of the general population. The scenarios considered in this deliverable, however, are not those of a society in which there is *merely more* of the same DiDIY as there is today. What we evaluate here, instead, are scenarios, and risks, of a society in which the possibility to practice DiDIY is, by and large, just one more, *really commonplace*, "service" or opportunity. Something, that is, that is not only concretely accessible but *is* actually used, every time it is needed, by the *great majority* of schools, businesses, public administrations and average individuals.

More explicitly, we look at a society in which tools and services for digital manufacturing are as commonplace and trivial as ordinary printing or photocopying shops and services are today: a set of opportunities, and associated rights, that are considered necessary, given for granted, and practically accessible for everybody. Regardless of how many individuals actually *own* a personal printer or copy machine, or of how many use one on a regular basis, or of how many copies they make.

In addition to this, while the narrower view of a DiDIYer is that he or she is an individual, here we also consider the broader view described in the DiDIY Knowledge Framework[2]: we consider, that is, also scenarios in which the ones engaging in DiDIY are small, organized *groups* of individuals working together towards a common goal, from school classes to company departments, small businesses, or even whole communities.

In this context, the risks presented here fall in two broad categories. In general, as it will be shown in the following Sections, there are both cases in which *more*, *unchecked* DiDIY than today constitutes a risk for society; and cases in which, instead, it would be risky to not have *much more*, (properly regulated and supported) DiDIY, because it could bring new, positive opportunities, or at least better options to deal with already existing problems.

We also look here at the private or public roles of individual citizens. Individuals can minimize, or increase, the risks of DiDIY for society in two ways: one is by directly, regularly *practising* DiDIY themselves, that is becoming real "DiDIYers", or as it is more commonly said "makers". The other way, which is at least as important from the point of view of this deliverable, is by direct or "indirect" public support, or contrast, of DiDIY. Activities in this category range from proposing new laws, regulations or projects that facilitate, or limit DiDIY, to occasionally renting DiDIY machines or services, for manufacturing one object from designs downloaded from the Internet.

The former case is, by definition, part of the official responsibilities and duties of, at least, EU and Member States lawmakers, policy experts, academy and schools. The latter case instead, while not being DiDIY in the strictest sense, may greatly increase the economic viability of fablabs, makerspaces and other services that *actual* DiDIYers need to operate.

2 The narrower and broader views of DiDIY and DiDIYers are described in D2.4,"Knowledge Framework – Revised version": http://www.didiy.eu/public/deliverables/DiDIY-d2.4-1.0-pub.pdf.

Finally, it is important to point out that, just like the DiDIY Project itself, this deliverable is about *all* forms of Digital DIY, not just the one that is most popular and covered by mainstream media so far, namely 3D printing. Digital DIY, instead, consists of all forms of manufacturing (including, in a broader sense, production of *immaterial* artefacts, from music to websites) that are practically feasible, and widely accessible, only thanks to digitally controlled machines. This includes new versions of traditional products and practices still used in "low-tech" activities. Indeed, some of the most meaningful long term impacts of DiDIY may come just from DiDIY applied to primary needs (food, clothes, shelter, etc) or on materials like wood, food or textiles, with technologies different from 3D printing.

The rest of this section introduces some high-level issues and, for each of them, describes how Digital DIY may have an impact on them, depending on how it is, or it is *not*, practised on a large scale, and regulated.

2.2 Safety, privacy and security

2.2.1 General issues

In general, DiDIY greatly increases both the opportunities to manufacture very dangerous objects, and those to make, customize or use even initially safe objects in potentially dangerous ways. In a society where DiDIY were really commonplace, cases of the second type would be much more frequent than those of the first, to the point that they may cause more harm, overall.

In a DiDIY society, in fact, we may have complex toys, autonomously designed and manufactured without sufficient skills, which may hurt children. We may have chairs and other furniture that breaks more easily or more unpredictably than their mass-produced counterparts. DiDIY-produced spare parts for cars, home appliances, drones and many other objects, which may all be causes of serious accidents, both for the DiDIYer who manufactured them and, above all, for other people.

Things may get even more complicated with DiDIY applications to the Internet of Things (IoT). In the context of this deliverable, by IoT we mean adding remote control, monitoring and generally any data exchange capabilities through the Internet, to virtually every object that runs on electricity, from anti-theft systems to car accessories and home appliances. Some people believe that everything that carries power will be connected to Internet eventually. In order to understand the DiDIY implications of such a vision, we may look first at some non-DiDIY cases.

In December 2016, the digitally controlled heating systems of at least two buildings in the Finnish city of Lappeenranta were knocked down by remote attacks that forced them to reboot continuously.[3] In 2015, two researchers demonstrated that they could remotely hijack a Jeep's digital systems over the Internet, prompting a recall for 1.4 million vehicles by Chrisler; in 2016, the same researchers announced the discovery of other vulnerabilities in the same systems[4]. Attacks like these, which may target any digitally reached product, are already possible on industrial products, manufactured by professionals under strict controls.

How will DiDIY change this picture? On one hand, the possibility of attacks (and the amount of actual damage) may be much bigger with products designed, configured and installed without any industrial-level quality control, and without relying on "security through obscurity" that is on keeping designs secret to not expose design flaws or weaknesses to criminals. On the other hand,

3 http://metropolitan.fi/entry/ddos-attack-halts-heating-in-finland-amidst-winter.
4 https://www.wired.com/2016/08/jeep-hackers-return-high-speed-steering-acceleration-hacks.

DiDIY in this field would very likely consists of self-assembly and configuration of a large variety of Open Source software and hardware, all with designs that everybody can audit, test and modify. Large deployments of many devices of this kind, all with different components and configurations, may make the overall system much more resistant to large scale attacks.

In any case, the IoT DiDIY objects connected to the Internet will be only a part of the DiDIY universe. Safety risks for third parties will be present at least in all applications of DiDIY to the production of objects used for professional activities, which may have consequences both for employers and customers. An example may be a restaurant owner that uses DiDIY to build or customize the furniture, kitchen appliances, 3D printers for food[5], fire alarms... of his restaurant.

At the same time, as it will be discussed in another section of this deliverable, the same applications of DiDIY may be a boon for the economy, by keeping many small businesses economically viable, or by enabling the creation of new companies. Therefore, it could be possible to leave space to such implementations, even if they may create more risks, in two ways. One is proper education, to increase awareness of risks and how to avoid them; the other is creation of a regulatory and insurance framework that helps to minimize the risks of DiDIY practices, at least for third parties.

These risks, that is the factors that may make a DiDIY product (as well as its fabrication!) less safe than an industrial one, include first of all: design flaws, errors in the assembly and configurations of the DiDIY machines (3D printers, CNC mills, laser cutters, etc..) or their software, raw materials that are unsafe, or at least unfit for the intended use (e.g: non food-safe plastic for manufacturing of kitchen tools).

Other risks include performances more variable from copy to copy of the same product, or much more variable over time. This fact would also make more difficult to estimate how long a warranty should last, and a product be discarded, or maintained. Finally, there are all the problems related to proper disposal and recycle. A situation like this presents serious challenges to insurers, but also big opportunities, if properly regulated and supported. Some insurance companies have already started to study these scenarios[6], but they still seems a minority, and need more support, or at least encouragement, to enter this field.

2.2.2 Privacy and identity theft

Besides the safety risks outlined above, DiDIY can create privacy risks whenever it is used to produce, or manage, devices that capture, carry or generate personal data. Today, it is possible to self-build sophisticated home automation or anti-theft devices thanks to relatively affordable tools and components, and to designs, documentation and support easily available through the Internet. But the same devices may be used to spy or track relatives, friends or coworkers.

Luggage approved by the USA Transportation Security Authority (TSA) must have a lock that can be opened with one model of Master Key. This rule has been instituted to allow TSA officials, that is the only people supposed to own copies of the Master Key, to quickly inspect travelers' baggages in airports. But shortly after official photographs of this key were published online, some DiDIYers were able to 3D print working Master Keys[7] by just looking at those photographs. They proved, that is, that thanks to the combination of DiDIY and of that TSA decision, everybody with a 3D printer and the skills to use it could "spy" into the luggages of millions of people.

5 http://foodink.io and also http://www.ilsole24ore.com/art/food/2016-10-28/cibo-stampato-3d-ecco-pane-pizza-e-pasta-130736.shtml.
6 http://www.didiy.eu/blogs/swiss-re-insurance-company-developing-claims-program-3d-printing.
7 https://3dprint.com/143860/tsa-master-keys-hacked-again.

In August 2016, police officers in the USA were able to unlock the smartphone of a murder victim with DiDIY techniques even simpler than 3D printing[8]. Three years earlier, the biometric hacking team of the Chaos Computer Club had already created a fake finger that *"successfully bypassed the biometric security of Apple's TouchID"* system by simply photographing a fingerprint of the user from a glass surface[9], [10].

In 2012, a team of Spanish researchers was able to recreate iris images, from digital codes of real irises stored in security databases, with an 80% success rate[11]. It is possible that the iris images can be obtained directly from "high-resolution images found in Google searches"[12].

Today, stealing these biometrics data, the codes of contactless credit or ATM cards, or those of electronic passports or other ID documents, is possible with Arduino microcontrollers and other inexpensive, easily available DiDIY components and software[13],[14].

So far, devices and techniques like these have been almost exclusively used in the two "extreme" cases. We have law enforcement officials authorized by court orders or security researchers on one side, and relatively few full time criminals, to violate privacy or steal personal data, on the other. Increased access to DiDIY makes much more likely that the same devices and techniques could be illegally used by many more people, even occasionally.

The positive side of this scenario is that, unless regulations and other restrictions make it unnecessarily difficult, the same increased access to DiDIY would also give to many more people the possibility to develop their own countermeasures, or at least put much more pressure, on security industry and regulators alike, to deploy more secure products.

This said, the ones above are all examples of how DiDIY may be used against single, previously targeted individuals, or in the worst case on just a few individuals at a time. Even bigger privacy violations and theft of personal data, however, may occur as a consequence of DiDIY in areas like internet access networks[15], and in general all "Internet of Things" applications of DiDIY. In both cases, the same considerations done about safety in the previous part of this section apply: on one hand, usage of unregulated devices may increase the probability that sensitive data transmitted or stored with them are intercepted. On the other, the possibility to experiment and customize with non-standard security settings routers, anti-theft systems and so on, may make them even more secure than their commercial counterparts, maybe to the point that not even lawful interception or data analysis by police forces may succeed.

2.2.3 Safety, health and ethics

Some DiDIY applications are more complex to deal with than the ones that we just presented. These are the applications that, besides carrying both negative impacts on employment and serious safety concerns, also raise issues, and create risks, at the ethics and equal opportunities levels. As examples of these applications, we first present biohacking and then gun control, which provide (especially the second case) many inputs reusable also in other sectors.

8 http://www.theverge.com/2016/8/2/12350214/phone-unlocked-paper-fingerprint-spoof-3d-print.
9 https://www.ccc.de/en/updates/2013/ccc-breaks-apple-touchid.
10 http://thehackernews.com/2015/03/iris-biometric-security-bypass.html.
11 http://www.bbc.com/news/technology-18997580.
12 http://www.forbes.com/sites/thomasbrewster/2015/03/05/clone-putins-eyes-using-google-images/#2935242d4f85.
13 https://www.bishopfox.com/resources/tools/rfid-hacking/attack-tools.
14 http://www.eweek.com/security/hacking-rfid-tags-is-easier-than-you-think-black-hat.
15 http://wwwdidiy.eu/blogs/things-network-digital-diy-commons-based-iot-datanetwork.

Biohacking is a technology that involves the ability to build bones and various kinds of human tissue, and eventually whole organs, layer by layer, in a digitally controlled manner, using cells as raw material([16], [17]). Similar procedures may be applied not just to the production of custom drugs for many diseases[18], but also to their distribution. It may be possible, that is, to have labs in remote areas that keep in stock only the raw, basic ingredients of drugs, and produce with them pills or other medicines on demand, possibly customized for each patient.

These technologies may greatly reduce the current shortages of organs available for transplant, and concur to reduce both the cost of drugs and surgery, and the time needed for testing new drugs and therapies. At the same time, they create several risks even without any literal application of DiDIY, that is even they are only applied by professionals, inside ordinary hospitals and research centres and according strictly controlled ways and facilities.

First, the technology could also be used to enhance “normal” human capacities, e.g. by printing stronger bones or muscles less susceptible to fatigue, which could have applications both in the military and in competitive sports. To the extent that 3D bioprinting is used in such cases, the ethical concerns typically raised about the general issue of human enhancement will extend to it. The three most important such concerns are safety, fairness, and coercion. The issue of safety is not specific to enhancement uses of bioprinting: it is equally important to ensure quality control in the context of treatment. It would be crucial to at least ensure that those who chose to use such interventions for purposes of enhancement are properly informed about any risks involved.

The same technologies, however, may also be used in DiDIY fashion by unprepared individuals, with great risks for themselves or for public safety. DiDIY may also be used by unscrupulous doctors or clinics to produce, and then use or distribute for profit, counterfeit and unsafe drugs or medical equipment. The cases of actual “medical DiDIY”, that is for personal use, would be quite hard to prevent. The deliberate, for profit and on a large scale of the same DiDIY by professional organizations, instead, could be prevented by publishing official, open data about the legal supply chains of drugs and equipment. This may make much easier, not just by law enforcement but also by independent observers, to detect other, unauthorised producers and distributors of the same products.

In general, when it comes to DiDIY to already existing trends in medicine and healthcare services, but also to what has been defined as “Design-at-home viruses”[19], many of the same considerations of the next section about gun control still apply.

2.2.4 DiDIY and gun control

The number of potential victims of unregulated, irresponsible usage of DiDIY already discussed in the previous sections is very likely to be and remain, albeit low, much higher than that of victims of DiDIY weapons.

In spite of this, DiDIY weapons, especially firearms, probably are the DiDIY “application” most problematic to deal with, and with good reasons. First of all firearms, unlike all other products above, are objects mainly, deliberately designed to kill, even if they can of course be used in completely legal and pacific ways, e.g., sport tournaments. Another reason is that DiDIY

16 http://www.didiy.eu/blogs/design-home-viruses.
17 http://www.didiy.eu/blogs/ethics-3d-bioprinting.
18 http://www.theguardian.com/artanddesign/architecture-design-blog/2015/aug/05/the-first-3d-printed-pill-opens-up-a-world-of-downloadable-medicine.
19 http://www.didiy.eu/blogs/design-home-viruses.

applications to, e.g., surgery or dentistry still impose the participation of some professional. DiDIY manufacturing and usage of weapons, instead, may be done by lone individuals, without particular skills.

We already have several examples of these activities, with the most interesting ones coming, for the moment, from the United States and Japan. The USA are the "home" of projects like the 3D printed plastic gun called "Liberator" and the so-called "Ghost Gunner" [20]. The latter is a 1500 USD digitally controlled mill, specifically designed to manufacture untraceable metallic firearm parts.

From Japan, instead, we have what seems to be the first case of conviction for manufacturing, use and "promotion" of DiDIY firearms. In 2014 *Yoshitomo Imura received* a two-year sentence for manufacturing a 3D printed pistol (using a 3D printer worth less than 600 USD)[21] and sharing online both the videos in which he used the pistol, and the corresponding design files. The reasons for the sentence included the fact that "Imura could have caused major damage to society" for making the designs easily available, encouraging imitation and "making our country's strict gun controls into a dead letter". Today, however, the design files of the Imura pistol, or other guns directly inspired by it, are still obtainable from the Internet.

These examples show how DiDIY makes personal, unregulated and untraceable fabrication of (possibly undetectable!) firearms, and weapons in general, much easier and affordable than before, at least in theory. They also show that preventing their circulation online is extremely hard, to say the least. In practice, at least in the near term, criminals in need of reliable firearms will probably continue, for some time, to find it simpler and more convenient to get them on the black market, if not in stores.

In order to further put this threat in the right perspective, we should remember that there has never been the need to use DiDIY, to engage in personal fabrication of firearms and other deadly weapons. Historically, prisoners have always found ways[22] to build lethal tools, including firearms, with extremely limited means. The 1993 box office hit "In the line of fire"[23] already popularized the concept that it would be relatively easy to build (without DiDIY!) a pistol that metal detectors could not detect. In 2013, security researcher Evan Booth publicly documented[24] how simple it is to "find everything needed to wage war on an airplane" in the restaurants and shops of every airport.

These facts do not cancel the fact that DiDIY may make it much easier than it was even a few years ago to manufacture really, really dangerous weapons like automatic rifles, and that some new form of control and prevention of these specific risks is appropriate and desirable!

In order to analyse these risks and present possible solutions to the problem of "DiDIY gun control", it is useful to distinguish between:

- crimes, or accidents, actually committed thanks to DiDIY weapons;
- actual fabrication of weapons, thanks to DiDIY;
- production, study, possession and sharing of the related information, from 3D printing design files to any other documentation.

20 http://wwwdidiy.eu/blogs/digitally-manufactured-weapons-can-they-be-controlled.
21 http://www.didiy.eu/blogs/3d-printed-guns-imura-case-study-japan.
22 https://www.correctionsone.com/contraband/articles/1961780-15-deadly-improvised-prison-weapons-and-tools.
23 http://www.imfdb.org/wiki/In_the_Line_of_Fire#Composite_Pistol.
24 http://terminalcornucopia.com/#what.

The risks from the first type of activities are the easiest to evaluate and regulate. Homicide, armed robbery and similar crimes remain such, regardless of the origin of the weapons involved. Therefore, at least as a first approximation, there is no need to treat crimes committed with DiDIY weapons differently from those committed with traditional ones. On the other hand, in the long run DiDIY may increase the *number* of accidents or crimes committed with DiDIY weapons, or even the number of personal weapons in the streets, in such measures to change the whole scenario: this aspect is discussed in other parts of the present deliverable.

Activities of the second type must be treated differently because there are even legal uses of weapons, e.g., in shooting matches, or hunting, not to mention research. However, they introduce additional risks: in general, weapons manufactured without skills, machinery, procedures and raw materials that are not professionally defined, tested and monitored, are much more likely to hurt even their own users, and other people around them. The simplest and most effective way to deal with these cases, without forbidding them outright, could be the simple, automatic extension to DiDIY weapons of restrictions similar to those traditional ones, at least about their actual use and carry.

The third activity, that is “production, study, possession and sharing” of the information to make a weapon via DiDIY, is the most problematic one, because it is the precondition that makes the two other cases possible, especially the crimes. In parallel, it is very likely that the average skills and knowledge necessary to build a working weapon with DiDIY may become quite lower than doing the same thing without using any digital technology. The combination of these two things is certainly a problem.

How to deal with it? The most extreme solution seems the one already adopted in New South Wales. Australia, in 2015, when the local Parliament decided[25] to ban not just physical, 3D printed guns, but the design files necessary to manufacture them. The bill approved in 2015 defines the mere possession of “digital blueprints for the manufacture of a prohibited weapon on a 3D printer or on an electronic milling machine” an offence carrying up to fourteen years of imprisonment.

Legislation like this may have symbolical and also some deterrent effect, but also has several limits.

First of all, it is simply not enforceable as an effective preventive measure, and unenforceable laws often have a negative impact on the reputation of the police and the judicial system. So far, all attempts to find and prosecute people who illegally share files, of whatever nature, have not sensibly impacted such activities. The fact that there would be much less weapons design files than e.g. music files, and much less demand for them, would not make finding and prosecuting the sharers of such files easier. Quite the contrary, likely. Finding the files automatically via watermarking or digital signatures would not work, because changing even one byte in a design files alters its digital signature, but may not change its functionality.

Prohibiting the mere possession of certain files also makes it harder to decide (and accept, by the public opinion) where to stop. This makes the prohibition even less enforceable. There are many websites that contain instructions for building DIY weapons without using digital devices. Should not they be prohibited and punished with imprisonment too? What about saving a digital or paper copy of the same pages? But how could these prohibition be enforced, in practice? Equally hard to enforce would be allowing the online distribution of digital gun blueprints only in restricted circles, accessible only to people with a relevant permit. Regardless of enforceability, prohibiting the mere

25 http://www.didiy.eu/blogs/it-has-happened-legal-ban-digital-diy-files.

possession of files may have dangerous side effects, like being used as pretext for generalized online surveillance.

When looking at this problem, it is also worth noting that comparison of weapon design files with other types of dangerous “digital content” like child pornography, does not fully apply. Production of child pornography is, practically by definition, abuse of children, or at least an apology for certain crimes. Finding and blocking that content means documenting and prosecuting something that is surely a crime *already* committed, as well as other crimes directly related with it, since hardly any possible use or redistribution of those files could be legal.

Designing a firearm or documenting its manufacturing process, instead, are different actions at the ethical and legal levels, and ones that may also be practised just for study or research purposes. They may never ever go so far as actually manufacturing a weapon which, as we said, should be treated as a different case.

2.2.5 Summary of risks and concerns

The concerns above do not cancel the fact that DiDIY does increase the risk that people can self produce, without any traceability or control, lethal weapons. Punishing mere possession of DiDIY design files for weapons seems to have too many drawbacks at all levels, from ethical concerns to practical enforceability, to produce more positive than negative effects, in practice.

Punishing the (re)distribution of the same designs may also create dangerous side effects (e.g. be used as pretexts to set up or strengthen online censorship systems) and has the same practical limits of forbidding illegal file sharing. We should consider and recommend really great prudence in regulating this specific activity, and in no way treat it, in and by itself, as an offence as serious as the actual DiDIY manufacturing of weapons.

As far as actual DiDIY production (regardless of usage) of weapons is concerned, the same laws that regulate, or forbid such activities may apply, or be extended to cover research purpose, or use of the weapons only in authorized facilities, or by registered users. This is a path of action that deserves further analysis.

Any attempt to preventively limit the capabilities of DiDIY manufacturing tools and software, instead, is going to be useless. First of all, programming a commercial 3D printer, or any of its parts, to effectively recognize the design files of weapons, or of their components, is like setting up automatic searches for the same files online. Even ignoring cryptography, such searches could really work only if there were a really limited set of 3D printable weapons, that is a really limited, and thus easily recognizable, set of design files for such weapons. In practice, things would be even more complicated, because digitally manufactured guns are assembled from any number of smaller parts. The real problem, however, is that it is impossible to program both 3D printers and the software for digital design, in any way that would prevent the use of those tools to design and build from scratch (parts of)... other 3D printers and design software, free from the same restrictions.

The most feasible solutions for controlling unsafe manufacturing, and illegal uses, of DiDIY weapons, seem to be the imposition of appropriate controls over some raw materials that are necessary for their production, but cannot themselves be digitally produced. In the specific context of digitally made guns, the best candidate for such a component would be the ammunition. That would still not be a… bullet-proof solution, because bullets may be produced with DiDIY and even gun powder may be produced “at home”[26]. However, those would be much longer and more

26 http://www.wikihow.com/Make-Gunpowder.

complicated processes, at least for people who need relevant quantities of reliable bullets or gun powder. Therefore, gun powder, or plastics strong enough to be used in parts of firearms, seem to be better targets, for gun control in a DiDIY era, than design files, or 3D printers.

As final considerations for future discussion and policy making on how to handle these risks, we must point out two issues, to which we will return in the final parts of this deliverable. On one hand, the real danger coming from DiDIY-based personal fabrication of weapons like the Ghost Gunner is not just that some people will have guns who should not, which is bad enough[27]. The real danger is that Ghost Gunner will undermine all gun control – which is exactly the point of Ghost Gunner advocates. But gun control relies on the ability of the state to enforce it.

If the state cannot actually control the spreading of guns then it becomes rational for more people to buy a gun for themselves. If there is no police controlling then everybody does whatever they want, and we all suffer. On the other hand, what appears when looking at DiDIY weapons is just one more, real world example of the current limits of the central control that was so common in the industrial age. That kind of control is much less enforceable, in practice, in a network society, where people can directly share knowledge and files as they want. But this is something that has effects far deeper, and widespread, than those of DiDIY weapons as such.

2.3 Social divides

Many technology-related developments carry the risk of intensifying existing divides between people, or create new ones, and DiDIY is no exception. Some of these divides are in access to certain services, others are in relationships among people.

A first divide between women and men may be in their very perception of digital DIY and other current technological trends, like the Internet of Things: “women seem to be more inclined than men to think of IoT as revolutionary instead of an incremental evolution.”[28]. Some analyses[29] of project participation and contribution on DiDIY online communities also seems to suggest that, at least in the last 4/5 years, women have been more interested in projects with practical applications in everyday life, and men in (simplifying!) “technology for the sake of technology”.

DiDIY, or more exactly the ways in which it has been promoted so far, may also worsen the already deep divides between people with enough time, knowledge, financial means and community support to actually benefit of technology, and everybody else. This divide exists both on the purely material plane, e.g. in the concrete possibilities to make and own better products of whatever kind thanks to DiDIY, and on the personal one (self-esteem, social status...).

Unless specific corrective actions are taken, in fact, poor or less educated people may likely have less access than others to many cost and practical benefits of DiDIY, from custom furniture to energy-saving products for their homes. The most relevant consequences, however, may be in DiDIY applications to healthcare, from bioprinting to custom prosthetics, and most of the other cases presented in the healthcare section of this deliverable. Even with theoretically equal access to, and assistance from, doctors and DiDIYers, in fact, citizens with lower education and little to no free time available after work and commuting may be disadvantaged. Namely, they may find co-

27 http://www.didiy.eu/blogs/end-gun-control-digital-diy.
28 http://www.didiy.eu/blogs/something-about-social-perception-DiDIY.
29 http://www.didiy.eu/blogs/can-we-say-something-about-who-didiyers-are and http://www.didiy.eu/blogs/hacking-DiDIY-online-communities.

design, testing and daily usage of, e.g., custom prostheses made with DiDIY, harder to do than recurring to lower quality, but turn-key services available from standard healthcare services.

At the individual level, the general divide that DiDIY may worsen is well represented by these thoughts in a 2015 article by prof. Chrachra[30]:

- "Making is not a rebel movement... it mostly re-inscribes familiar values, in slightly different form: that artefacts are important, and people are not."
- "The problem is the idea that the alternative to making is usually not doing nothing—it's almost always doing things for and with other people"
- "Describing oneself as a maker—regardless of what one actually or mostly does—is a way of accruing to oneself the gendered, capitalist benefits of being a person who makes products."
- "A quote often attributed to Gloria Steinem says: "We've begun to raise daughters more like sons... but few have the courage to raise our sons more like our daughters." Maker culture, with its goal to get everyone access to the traditionally male domain of making, has focused on [raising daughters more like sons]. But its success means that it further devalues the traditionally female domain of care giving, by continuing to enforce the idea that only making things is valuable."

On the positive side DiDIY can provide, starting from young people but without being limited to them, more opportunities and motivations to overcome the same divides. DiDIY also is, for example, a great opportunity to interest more girls in STEM subject. In general, as described in paragraph about education, DiDIY can do this both providing more ways to teach and learn traditional subjects, and by means of multi-disciplinary or extracurricular activities. DiDIY may also increase the affordability of certain medical devices and treatments, due to the fact that it is largely based on Free Software and Open Hardware designs, if restrictions on personal or non-profit use described in the "Creativity and Innovation" Section do not block it.

2.4 Education and lifelong learning

In ordinary schools and universities, Digital DIY constitutes a great resource in at least two ways: one is to self build (or, more likely, to ask a fablab to do so) products then used in traditional activities. Budget-wise, many forms of DiDIY are economical enough to be accessible also to homeschooling parents, or schools in disadvantaged areas, especially if working in cooperation with the closest fablab.

This kind of DiDIY practices does not directly innovate or change anything in education, as it is just an extension of the "self-support" that has always happened in and around schools. At the same time, it can keep education sustainable, in an age of low funding for schools, by cutting the total costs of ownership of certain tools; and it can stimulate interest in using the same techniques and approaches in more innovative ways.

More in detail, teachers and students can benefit of DiDIY to stimulate and exercise their creativity, knowledge and skills in ways not possible otherwise. DiDIY may help teachers to teach certain concepts, even to pupils who may be "unreachable" with traditional methods[31].

30 http://www.didiy.eu/blogs/are-non-DiDIY-ers-less-valuable-humans.
31 http://www.didiy.eu/blogs/digital-diy-makes-art-more-accessible-disabled-people.

Thanks to DiDIY, the students of a Greek high school learned and above all applied[32] together, by building one underwater Remotely Operated Vehicle, “basic principles of Science, Hydrodynamics, Engineering, Soldering and Assembling”. Still from Greece, we collected examples[33] of how robotics can benefit young students, including: actually understand programming and algorithmic thinking; designing for dynamic environments, that is learning to predict unforeseen circumstances and plan ahead; simultaneous, harmonious training in electronics, mechanics and informatics. In general, DiDIY in schools may also attract students towards STEM disciplines.

Equally interesting, albeit limited to some cases, is the application of DiDIY to education, and integration, of children with special needs. The same report from Greece above include descriptions of how “the mere presence, in a class, of a robot that can be customized in many ways makes children with special needs blend and participate with the others, more than they would have done without the robot as a catalyst”.

The same advantages, obviously in different forms, are possible in adult education, from lifelong learning programmes to re-qualification of unemployed workers (this topic is also covered in the section about the job market of this deliverable).

The risks of not practising, or facilitating, DiDIY as one more tool available in schools is to make schools, that is their students, miss all the opportunities above. The main risk of doing the opposite is to waste already scarce resources, if DiDIY is dumped on schools without real involvement and preparation of teachers, and without exploiting local knowledge, or adapting the DiDIY activities to the actual needs of the students, as well as to the needs (and job opportunities) of the local community around each school.

2.5 Creativity and innovation

On one hand, DiDIY can support enough new cases of innovation and creativity that the risks coming from limiting or, in some cases, prohibiting it, cannot be dismissed. In the current economy, many new, innovative companies and services in all sectors could not even start without DiDIY. But even long established small and medium businesses (SMEs) in traditional sectors of the economy may remain economically viable only thanks to the types of creativity and innovation that are possible only through DiDIY.

A good example of these situations comes from ceramic artist Steffen Hartwig. The impact of DiDIY in Hartwig’s work is relevant because it is of such a general nature that comments about it[34] remain valid, in one way or another, in practically all crafts, and for many small businesses, no matter how “low tech” they may have been until today. The first relevant thing in Hartwig’s way of working, in fact, is how he used DiDIY to enhance his creativity and innovate: “Hartwig’s work stands apart. His self-designed ceramic 3D printer, extruder, and software are tools still deeply embedded in traditional workflow, and the 3D printed pieces are imbued with intentional imperfections, resulting in ambiguous yet alluring artefacts.”.

The second thing is how such creativity and innovation were technically possible, and economically affordable, only thanks to “copying”, that is reusing and reassembling openly available knowledge and standard materials: “The hardware is self-designed, but inspired by the many DIY delta printers

32 http://www.didiy.eu/blogs/how-some-greek-students-built-their-very-own-DiDIY-underwater-robot-vehicle.
33 http://www.didiy.eu/blogs/DiDIY-robotics-makes-all-children-work-together.
34 http://www.didiy.eu/blogs/digital-diy-helps-artisans-produce-better-products.

that already exist. The construction is quite simple, based on widely available components and easily machinable materials.”.

Taking just two more, and very different, sectors of the economy as further proof of the potential of DiDIY in this kind of creativity and innovation, we may mention jewellery, in which 3D printing, laser engraving and similar techniques are becoming more and more popular every year[35]; and agriculture, where during our research we have found DiDIY applied in the same way as Hartwig’s for autonomous tractors[36], more productive beehives[37] and milking machines[38].

The examples just cited help to explain what are the risks of not supporting this sort of DiDIY-enabled creativity and innovation among artists, craftspeople, SMEs and disadvantaged communities: those risks are the loss of many opportunities both for common creativity, and for economic development (or survival, in extreme cases).

On the other hand, active practice and official support of DiDIY can disrupt, with non-negligible negative impacts, both already existing activities, that are based on past creativity and innovation, and in general the traditional approach itself to these issues. The opposite is also true, meaning that existing norms about “Intellectual Property” risk to seriously limit the benefits of DiDIY.

The combination of 3D scanning with DiDIY is already making cheaper and easier to manufacture very good replicas of many products. In the foreseeable future more and more people every year will have access to such opportunities. In many cases there may not even be the need for 3D scanning, thanks to projects like the “Large Dataset of Object Scans”[39] which in early 2016 already contained “more than ten thousand 3D scans of real objects [of all kinds]: from shoes, mugs, and toys to grand pianos, construction vehicles, and large outdoor sculptures.. [all] irrevocably placed in the public domain”. From a purely technical point of view, the tools and capabilities to expand a dataset like that until it reaches the same scale and popularity of Wikipedia, providing 3D scans of most existing objects, are already available.

This situation has created legitimate concerns, even if sometimes they are formulated in misleading ways such as “how will 3D printing combat counterfeiting?”[40]. In and by itself 3D printing, or any other technology used in DiDIY, should combat counterfeiting no more than shovel manufacturers should combat people falling into holes in the ground, or steel foundries should combat illegal firearms.

The current Intellectual Property framework does not make the situation easier, and is unlikely to improve in the short term. The recent extension of copyright for designs from 25 years to the life of the designer plus 70 years[41] in UK, for example, may likely mean an overall copyright term of over 100 years for furniture and other designed objects. Before this change, the same objects were protected by “design rights plus a shorter copyright term. [With design rights] you’re absolutely and one hundred percent free to make copies of it for your own use with your own tools and materials. When something is under copyright, you are not.”. According to Pirate Party founder Rick

35 https://3dprint.com/149378/3d-printing-jewelry-design.
36 http://www.didiy.eu/blogs/status-digital-diy-and-DiDIY-project-some-notes-paris.
37 http://www.openbeelab.org.
38 http://www.biblio.liuc.it/liucpapersita.asp?codice=343.
39 http://www.didiy.eu/blogs/large-dataset-objects-shows-relevance.DiDIY-project.
40 http://www.didiy.eu/blogs/counterfeiting-really-biggest-deal-3d-printing.
41 http://www.didiy.eu/blogs/copyright-extension-assault-digital-diy.

Falkvinge[42], under this new regime DiDIYers "will be prohibited from using 3D printing and other maker technologies to manufacture such objects for a full century".

In practice, if confirmed, rules like these may prohibit for-profit, legal production of copies of designer objects with DiDIY (even if, as discussed in the "Consumer Rights" section, the original designers were not around any more, to collect the proper rewards for their creativity). As far as actual, for-profit counterfeiting is concerned, such rules would not make fighting it easier, and may even backfire: having to protect, in every moment, everything designed over the last century, means having to search and prosecute many more cases of IP infringement, that is increase the workload on courts and police forces.

Regardless of these considerations, it would be almost impossible to track and block personal production, with or without DiDIY, of copies of designer objects. The possibility to produce such copies would still reduce the demand for authorized ones, though.

In spite of this, strong limitations to "copying" would constitute a non negligible obstacle to DiDIY creativity and innovation practised for *non-commercial*, private or educational use. Should such copies be illegal? Today, in several cases they would not. But even when they would, how could they ever be detected? Excesses of zeal against non commercial, private practise of DiDIY may produce more unenforceable laws, and limits to individual creativity, or even livelihood in extreme cases.

Another way in which traditional creativity and ways to manage it will clash with DiDIY more and more often in the future is related to embedding of proprietary software in all kinds of products, from tractors to cars and fridges, in ways that limit competition and consumer rights. Embedding software in any product makes it much easier to customize or maintain it via DiDIY. But corporations are trying to limit this possibility of tinkering, arguing that their customers cannot modify the products they legitimately bought, because it would hurt creativity.

Tractor manufacturer John Deere, for example, claimed that customers who bought its tractors actually bought just a license to operate them, and that allowing them to freely alter the software of those vehicles would "make it possible for pirates, third-party developers, and less innovative competitors to free-ride off the creativity, unique expression and ingenuity" of the developers of that software.

One risk of copyright extensions like the last one in the UK, or of legislation that supports, even for DiDIY, positions like those of John Deere is that even the companies who push for such legislation may, in the long run, be harmed from it: forcing small farmers to "rent" tractors or making them not maintainable after a few years, or autonomously by the farmers, may leave the latter with little alternatives than quit their activity, massive infringements of unenforceable laws (!)[43], or adopting DiDIY in even more radical ways, mentioned at the end of this paragraph.

Another risk for innovation and creativity that should not be overlooked is the one of "orphan" physical works of design, that is physical products in the same legal status of "orphan works" in which books, music and other creative works fall when their copyright holder cannot be found anymore: a problem the USA Copyright Office, among others, has acknowledged to be [44] "for good faith users a frustration, a liability risk, and a major cause of gridlock in the digital marketplace."

42 https://www.privateinternetaccess.com/blog/2016/08/3d-printers-break-eu-expands-copyright-furniture.
43 http://www.didiy.eu/blogs/uk-makes-private-copying-illegal-again.
44 https://www.copyright.gov/orphan.

The combination of today “Intellectual Property” with the frequent outsourcing of design and cross-licensing deals, in fact, has the same effect on physical products that it has on immaterial creative works: when a company goes out of business, or just stops manufacturing something, nobody else is legally allowed to do it for many years. Sometimes, the situation is so complex that even figuring out who should give permission for what is really a hard task. This can stop innovation and creativity, not protect them. Extending the prohibition to make copies of designer objects to many decades risks to make this problem worse.

In general, we cannot exclude that losses from blocking (assuming that it would be possible..) potential future innovation and creativity via DiDIY is going to be comparable, or bigger, than the losses (in jobs, potential royalties, jobs, etc.. if DiDIY-based copying were tolerated or encouraged) in potential future gains for/from past innovation.

Besides, and regardless of the intrinsic validity of certain positions, illegal copying and hacking of existing products may not be the biggest attacks from DiDIY to creativity and innovation as we know them today. At least in the medium and long term, the greatest risk for existing artists, designers, corporations and in general all commercial interests based on creativity and innovation, may be the nature itself of DiDIY.

It is quite likely that most products and practices of DiDIY will happen without any IP infringement, or entrepreneurial drive for innovation. How should or could society, from individuals to insurance companies, handle the risk that market demand for “designer” products, be they clothes or tractors, shrinks without any counterfeiting or other IP violation? What if, that is, demand for “original”, commercially branded products, decreases not because more consumers can make or buy cheaper copies of those same products thanks to DiDIY but because, thanks again to DiDIY, they have much more opportunities to design and make themselves unique products, or just to clone products in the public domain that satisfy their needs?

2.6 Environmental footprints and consumer rights

Environmental footprint, waste and consumer rights are, in many ways, highly interdependent issues. Today, everybody is called to minimize their overall environmental footprint. But because of DiDIY waste and energy consumption may increase, not decrease, in many cases.

Wider adoption of DiDIY means that, every year, more people may require more tools, or produce more objects just for leisure, that are based on plastic, microelectronic circuits and other non recyclable, possibly hazardous substances. Even some DiDIYers have already noted that[45] “[many 3D-printable designs found online] mostly reminded them of once must-have toys that eventually contribute to the clutter in our lives”.

At the same time, when considered as consumers, European citizens are entitled today to own the greatest possible variety of products they can afford, and encouraged to enjoy that variety. The mainstream logic of private ownership also implies that people should get the most from their money, and have full control over the products they legitimately acquire[46].

These days, instead, when some products (especially consumer electronics) break, it is quite often both easier and cheaper (even if it produces lots of unnecessary waste) to buy new ones[47]. Repair is

45 http://www.didiy.eu/blogs/spare-part-its-hard-find-unless-one-uses-DiDIY.
46 http://freeknowledge.eu/blogs/right-to-repair.
47 http://www.didiy.eu/blogs/right-repair-also-right-digital-diy, and also http://www.didiy.eu/blogs/beyond-right-repair-digital-diy-and-right-keep-buying.

actively discouraged by several means, from simply refusing to publish repair information and manuals to using digital locks or copyrighted software. In order to fight this situation, a "Right to Repair" movement composed by consumer advocates, repair professionals and ordinary individuals is actively promoting legislation that would "make it harder for companies to keep repair information proprietary"[48].

Less discussed than the "Right to Repair", but at least as important in the context of this deliverable, is what we may call the "Right to Keep Buying", which is another way in which DiDIY may constitute a risk for the current economy.

What happens today when people do not buy some original product because, regardless of its price, it is not possible to buy it any more? What happens, that is, when the only entity that originally did or still could, legally make that product has gone out of business, or simply decides to stop production for whatever reason? Theoretically, consumers should be able to buy or keep whatever they want, as long as they want (and as long as it is legal, of course).

In practice, instead, market strategies and physical "orphan works" prevent these opportunities, besides placing on creativity the limits already discussed in a previous section.

So far, all people finding themselves unable to repair or keep buying a specific product could do was petition the manufacturer to resurrect that product, or buy a used one. DiDIY changes this picture, at the technical level, by making it much easier to build, or commission, perfect replicas of many products, and also to repair them. It is important to realize that this possibility does not exist only for complex or expensive objects! It is equally available, and much more important, for practically every professional or household product, including objects, like fridge handles, which are really simple but also quite hard to make without DiDIY[49].

By doing so, DiDIY creates more ways to reduce waste and protect consumer rights, something that is obviously a great risk for many commercial interests. Widespread practice and support of DiDIY would give many more people may more ways to self-produce many products, or their spare parts. But they would also have many more opportunities to co-design from scratch, and produce, less wasteful, highly modular, fully extensible products of all sorts, that are much easier to maintain and repair. Online collaboration and sharing of *original, Open Source DiDIY documentation and design*s (of works, that is, not attackable at all as counterfeiting, or other IP infringements) greatly increases the size of this phenomenon, and thus the risks for commercial strategies that rely, among other things, on artificial scarcity and planned obsolescence.

DiDIY, for example, has many practical applications in "joint [based] design" of large objects, like furniture, that is in designing objects made of very simple parts of common materials (e.g., scrap wood, sheets of metal) that are assembled with custom made, 3D-printed small joints[50].

DiDIY also makes it easier to build, customize and maintain whole, complex home appliances like "The Increvable"[51]: a washing machine designed to be shipped as an IKEA-style assembly kit and last fifty years, by being highly modular, easily repairable. The Increvable is also controlled by software that its owner may easily adapt to his personal needs, as well as to different local electricity tariffs, or rules. While the Increvable is the creation of a single designer, who conceived it for traditional production, it is made to order to be autonomously customized and maintained via

48 http://www.didiy.eu/blogs/right-repair-also-right-digital-diy.
49 http://www.didiy.eu/blogs/spare-part-its-hard-find-unless-one-uses-DiDIY.
50 http://www.didiy.eu/blogs/digital-diy-brings-modular-furniture-next-level.
51 http://lincrevable.com.

DiDIY. Above all, the Increvable is a great demonstration of how it is already possible to co-design online, from scratch, other washers or any other household product of comparable complexity.

In practice, these possibilities are heavily limited today by the fact that manufacturing an object with any DiDIY technology often still costs quite more, in time if not in money, than buying an identical object produced in traditional ways. Therefore, DiDIY is viable only when the object to be manufactured cannot be bought, for whatever reason, or when what matters is not the product as such, but the skills or pleasure gained by making it. On the other hand, thanks to the Internet and the already mentioned online databases of objects scans[52], perfect copies of existing objects need to be produced just *once per object, worldwide*.

The same increasing practical feasibility of the "Right to Repair" or keep buying, that reduces waste and protects consumer rights also introduces safety and liability issues. If the reason why some product went out of production was, for example, that safer childproofing regulations made it illegal, or that some research found its components to be toxic, it would be in the public interest to not allow its production and distribution via Digital DIY, regardless of any IP issue.

Summarizing, DiDIY widely applied to production and repair of consumer goods may be a great opportunity to protect consumer rights, and to foster social and environmental sustainability. It is also for these reasons that it has been claimed that *"now a fixer – rather than maker – movement is needed"*[53]. As far as laws and policies about creativity and innovation are concerned, the risk is that these opportunities are lost, unless repairing ones' own goods remains "fair use", and the related exemptions to most IP rights that already exist in many legislations[54] are strengthened.

2.7 Healthcare

As it happens with other industries and services, the digital technologies that make DiDIY possible are already used, by traditional healthcare providers and manufacturers, to disrupt that market. In 2016 the Dubai Health Authority announced plans to offer 3D printed artificial limbs by 2025, at costs just above 100 USD, plus its intention to offer "ceramic teeth in less than 20 minutes, 3D printing in orthopaedic surgeries and casts, which will speed the healing process of patients by 40 to 80 per cent". In Singapore, a team of engineers has developed a technology to 3D print "customised pills on the spot", each with a shape that makes it possible to release drugs at a different rate.

UK hospitals are testing a medical device called MediPi, built around a Raspberry Pi board, that allows patients to monitor their vitals by themselves, and send the encrypted results directly to their doctor or hospital. The prototypes cost about 250 GBP, against up to 2000 GBP/year for current commercial devices. Unregulated hearing aids, much cheaper than traditional ones and usable without any help by an audiologist are already easily available in the USA and Europe.

Even outside these large scale projects, direct cooperation between DiDIYers and individual doctors is already producing medical tools and other objects or services used in healthcare. Some of these products are custom projects, fully tailored to the actual needs, capabilities and body size of one

52 http://www.didiy.eu/blogs/large-dataset-objects-shows-relevance-DiDIY-project.
53 http://www.DiDIY.eu/blogs/need-digital-diy-movement-repair.
54 "Creating a legal framework to facilitate the digitisation and dissemination of works and other subject-matter which are protected by copyright or related rights and for which no rightholder is identified or for which the rightholder, even if identified, is not located — so-called orphan works — is a key action of the Digital Agenda for Europe" ("DIRECTIVE 2012/28/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 25 October 2012 on certain permitted uses of orphan works)".

patient. They go from bikes for people with neurologic diseases[55] to assistive tools[56] and prosthetics limbs[57], usually at lower costs than the alternatives available without DiDIY, and with the added advantage of Open Source, freely reusable designs[58]. Other DiDIY projects for medicine are general purpose tools, like a 3D printed eye examination kit[59] reported to be very accurate, yet easy to manufacture "in the most inaccessible places", in only four hours, at the cost of 50 USD.

The above examples show that truly DiDIY versions of objects like the MediPi, the low cost eye examination kit or even certain hearing aids are already possible. But even much more complex services and therapies like those planned in Dubai and Singapore, however, are not so far from the reach of single doctors, or at least of small, independent and low budget organizations in every country of the world. As a matter of fact the OpenCare project in Europe is already studying how to do just that[60].

Side by side with DiDIY for new products, but closely related to it, there is what we may call the "medical self-repair" phenomenon that is already happening today in developing countries. In Tanzania[61] an independent medical device repair technician "has a website where he shares information on fixing medical equipment such as infant incubators (shown in the picture), cardiac monitors and autoclaves". Of course, as a minimum, such ways of working void all existing warranties and even the mere online redistribution of the manuals is probably illegal. But it is the only option wherever authorized repair outlets are not present, or not affordable. Such DIY/collaborative repair of medical equipment may take place also across Europe, as a consequence of budget cuts, economic crisis and ageing populations.

In general, DiDIY in healthcare is different than in other sectors because (unless it is used by doctors to build their own tools, of course) it must involve, besides the user/maker, a doctor or other medical professionals that first oversees the design and manufacturing process, and then actually uses the DiDIY product. This does not mean that it is a development without risks, of course! The first, obvious risks to consider when thinking to widespread applications of practices like the ones presented above are:

- quality control of the DiDIY products and services. It cannot be excluded, at least in certain cases, that services and products that are really custom-made to match the specific needs of a single patient and laboratory will be of greater quality, for that specific patient or laboratory, than mass-produced ones. However, standard procedures to evaluate the results, and that *are feasible* also by DiDIYers, should always be applied!;
- information: at the same time, and as a minimum, much more awareness is needed about the possible risks implied by, so to speak, "work" on people's bodies with DIY objects, together with rules on how to make that awareness possible;
- isolation/alienation, due to healthcare (self) provided via machines, without human contact (see previous points).

55 http://www.didiy.eu/blogs/DiDIY-lets-every-child-ride-bicycle.
56 http://www.didiy.eu/blogs/serving-needs-sick-or-disabled-people-digital-diy.
57 http://www.didiy.eu/blogs/DiDIY-fossa-2015-between-open-chairs-robots-and-worms.
58 http://www.didiy.eu/blogs/glimpses-future-impact-DiDIY-healthcare.
59 http://www.odocs-tech.com.
60 https://playbook.opencare.cc/how_the_maker_movement_is_transforming_care.html.
61 http://www.didiy.eu/blogs/serving-sick-people-digital-diy-example-tanzania.

The projects cited at the beginning of this paragraph show that all these issues already exist, or will exist, even without any DiDIY, just because of commercial offers of the same services and the strong pressures to reduce healthcare costs worldwide. DiDIY greatly increases the scale at which this can happen, making it harder to monitor and prevent misuses, but also bringing more opportunities to many more patients. Both in "developing" countries and in poor, underserved areas of richer ones, the choice between DIY care and no care at all, for lack of money and/or personnel, will become more and more a non-issue, as awareness of the possibilities of DiDIY, and access to it, increase. In other words, it is likely that much more DIY healthcare with DiDIY tools will happen.

2.8 Workplace and job market

The technologies that make DiDIY possible are already disrupting workflows, jobs and the job market in general, inside traditional manufacturing companies. This is a trend that will continue for some time, because 3D printers and similar machines must still be optimized to achieve maximum efficiency. In the future 3D printing itself, which is considered today the digital manufacturing technology of excellence, may be often hidden by the integration of several making technologies within high-end digital manufacturing machines[62]. Eventually, such integration would very likely appear also in more economical products (self) built just for DiDIY.

Besides optimizing the assembly lines, DiDIY technologies and mindsets challenge existing companies both from the inside and from the outside.

Internally, DiDIY gives companies more ways to restructure all processes, not just manufacturing, and the organizations behind them. Warner Bros, for example, challenged all its employees to design and 3D print, in 30 hours, a new thing that could be useful at work[63]: "Participation was high and, without forcing any policy from above, or wasting money in equipment for departments that could have never been used it, to identify key pioneers at the company with the desire to learn and embrace 3D printers in their workplace. The context was a positive team building experience, filled with creativity, innovation and cross-collaboration among various departments and made a real change in the attitude towards 3D printing in a company [at a much smaller cost than other approaches]".

DiDIY can also be used as one more service to attract and keep customers. Makerspaces inside traditional shopping malls[64], together with digital manufacturing services by department stores, already take advantage of the same technologies used in DiDIY to maintain and increase their customer base. Even small retainers may partner with makerspaces to furnish and maintain their stores, or to offer repair services to their customers. The risk for them is to face bureaucracy and regulations about these matters so complex and expensive that only big companies can afford to deal with them

These offers can also introduce to DiDIY many more people than traditional, much more intimidating, makerspaces. In the future, both retailers and department stores that ignore this category of services may risk to lose customers. On another level, it is worth noting that a consequence of the same services, intentional or not, is also to make less DiDIY happen outside the "control" of the same players.

62 http://wwwdidiy.eu/blogs/standard-digital-diy-machine-future-might-be.
63 http://wwwdidiy.eu/blogs/intimate-approach-introducing-3d-printing-corporations.
64 http://www.didiy.eu/blogs/digital-artisans-reshaping-craftmens-work-through-digital-do-it-yourself.

From the outside, DiDIY is a risk for traditional companies because it may reduce the needs for more new, ever changing products, cutting both profits and jobs.

DiDIY, however, can also create or preserve other jobs, in businesses that are able to exploit DiDIY, or to offer it as a service. For some companies DiDIY may be an opportunity to reach more customers. If they published themselves the full original designs of each product they do not want to produce any more, maybe together with a list of "approved makers/fablabs" where consumers could go to have "official" copies, that could be a way to both keep customers "in the store" by proposing them new products at special conditions. This strategy may also be a way to expand in new markets, without setting up a full blown, traditional distribution and retail structure from the beginning.

Community makerspaces for examples, that is places that 3D print, CNC mill, etc, on-demand, would make "assisted" DiDIY accessible to many more people. In doing so, they would also create service jobs that cannot be outsourced and are attractive for young people, giving them both an alternative to migration, and skills they may reuse later on in other jobs.

A special place in this analysis is hold by artisans who, due to falling demand for quality goods, are struggling to stay in business. DiDIY has a remarkable potential for artisans. Large firms aim at standard products made in large volumes and pushed through marketing. Artisans and small businesses, instead, are often solely focused on the product sold to a local market, and operate with a do-it-yourself attitude privileging creativity and proactivity. Furthermore, the artisan business model is based on creating products closely fitting the unique needs of each client. DiDIY technology, which allows to create or manage objects with much less intermediaries and infrastructures than before, at affordable costs, appears particularly promising for artisans.

A typical example of this scenario is the WOVNS company. Thanks to DiDIY on demand, WOVNS can efficiently weave as little as one yard of a given design. Its customers are artists, designers, businesses, and hobbyists that need small runs of custom woven fabric at a reasonable price[65]. The web based platform of WOVNS lets them upload digital design files and get them translated into custom woven textiles suitable for applications like upholstery, pillows, bags, scarves, throws, dresses, and other home decor and soft goods products.

Today, many artisans and small companies still risk to miss opportunities like these, if they do not truly understand how DiDIY may support their creativity, and improve their products. They also need access to DiDIY tools, knowledge and support at low costs, and the possibility to experiment without huge investments. From this point of view, the main risk is that existing regulations, that were not conceived for the challenges they must face today, prevent the full adoption of DiDIY by artisans.

2.9 Economic growth

DiDIY does not necessarily create more economic activity[66], not of the kind that increases GDP at least. If it became really commonplace, it may contribute to reduction of international trade and GDP, instead. On the other hand, access to DiDIY services may be a boon for low-income individuals and communities. For the same reasons why it can be an obstacle to traditional economic growth, DiDIY may increase resiliency, both at the personal and community level. Applications of DiDIY with these effects go from DIY Internet access network in rural areas to

65 http://www.didiy.eu/blogs/wovns-bringing-personal-fabrication-jacquard-woven-textiles.
66 http://www.didiy.eu/blogs/taking-diy-next-level.

telemedicine, increasing local food production through hydroponics, crop and cattle monitoring, or keeping farming economically viable, by reducing its cost. An example of the latter application is the work of Matthew Reimer, a Canadian farmer. Reimer, without previous experience in programming or electronics, used DiDIY to hack his tractor, so it can follow and assist him in the fields[67]. As is, that specific DiDIY project may only be useful on very large, flat fields as in Reimer's case. Still, it is a good example and application of the point above, which we discussed at length in our 2015 paper on "Digital DIY for self-sustainability of rural areas"[68].

2.10 Active citizenship, self governance

DiDIY is an extremely varied phenomenon, but at least two of its characteristics are always present. To begin with, by definition DiDIY consists of, or at least greatly facilitates, highly decentralized, non-profit production of goods geared towards the needs of individuals and of small communities alike. In the latter case, DiDIY gives those communities the possibility to manufacture together more of the products that they need locally, by downloading designs from the Internet, out of a relatively small number of different raw materials.

Such communities may therefore fill their needs relying on much simpler, and more sustainable, supply chains (as long as Internet connectivity is granted, of course). Struggling urban or rural/remote areas may use digital manufacturing to leapfrog some stages of development (or economic recovery) in the same ways as they were able to adopt mobile communications. Networks of DiDIY hackerspaces and tool libraries can be used as educational and support services for such programs, if properly supported and coordinated by local public and private stakeholders.

In addition to local administrators, this first feature of DiDIY makes it a powerful tool also for all the non-profit groups whose goal is sustainable self-development of the local community, or mutual economic support among their members. Just like individual DiDIYers, these groups put utility value before exchange value in the goods or services they produce, and for this reason some of them are already using DiDIY to accomplish their goals[69]. It has been said that that groups doing so will redesign politics, if they already are not[70].

The second common characteristic of DiDIY is that its practice is greatly facilitated by familiarity with, and active participation in, distributed online communities. This means that, besides providing more resources for environmental and economical sustainability, pro-DiDIY policies may also, as suggested by third party articles[71] and research projects[72], stimulate and facilitate other ways to engage in active citizenship online.

In summary, community-level DiDIY needs more self-governance to work better. But self-governance initiatives find in the same DiDIY more ways to make their mission concrete, that is even more concrete reasons, for more citizens, to participate in them. In parallel, DiDIY makes people practice a skill that they can reuse in self-governance, that is familiarity with online platforms for collaborative work and citizens participation. Combined, these two facts may challenge existing power and organization structures from the bottom. Whether this is a risk or not

67 http://www.didiy.eu/blogs/status-digital-diy-and-DiDIY-project-some-notes-paris.
68 http://www.biblio.liuc.it/liucpapersita.asp?codice=343.
69 https://blog.p2pfoundation.net/making-sustainability/2016/03/12.
70 http://www.didiy.eu/blogs/digital-diy-global-redesigning-politics.
71 http://www.didiy.eu/blogs/digital-diy-can-give-new-life-and-higher-revenues-struggling-cities.
72 http://www.didiy.eu/blogs/leapfrogging-value-digital-diy.

for the communities heavily varies from case to case, but it surely is a trend to watch, and experiment with, in the next years.

2.11 Summary of risks and general challenges

The DiDIY-related risks, opportunities and challenges described so far are a combination of the flexibility and ubiquity of DiDIY with the ethical, environmental, social and economical pressures that Europe is facing today, and which would exist even without DiDIY. Some insights on the medium and long term effects of this combination on European society may come by the Cuban movement that artist and designer Ernesto Oroza called "technological disobedience".

Oroza gave that name[73] to the sum of "everyday creative practices of systematic disrespect towards the complexity, closeness and exclusionary characteristics of industrial objects". According to Oroza, in the 1990's, as a consequence of the embargo, the citizens of Cuba "became desensitised to designed objects and learned to disrespect their intrinsic 'authority', identity and original purpose, seeing them as a collection of parts instead. The Cuban manufacturing culture repaired and altered all kinds of objects, including vehicles. In order to do this, Cubans also invented, designed and produced the necessary tools and machines: "Cuban houses became archives, storage places, warehouses, workshops, design studios, production places and shops", creating a "completely new market with reinvented industrial products transformed thanks to a craft approach".

Of course, there are big differences between Cuba in the 1990's and today's Europe. Still, the description above may apply to any society that fits the initial hypotheses: a society, that is, in which practising DiDIY has become as commonplace as making a photocopy, or taking a picture with a smartphone. In such a society, even if DiDIY were only practised in the same ways as today, the sheer volume of DiDIY activities would create serious problems, if not supported by proper regulation and education. As far as Europe is concerned, the main "targets" of such challenges, besides the already mentioned one of "Intellectual Property", are summarized in the next paragraphs.

2.11.1 Unnecessary complexity

DiDIY exposes, possibly more than most other factors, what we may call the "peak complexity" of the current legal and social systems, thus making them more fragile, and harder to accept by citizens. Many of the problems that block adoption of DiDIY mindsets and activities among artisans and small businesses, for example, are not caused by DiDIY, or specific of DiDIY. During our meetings and interviews with makers[74], a recurring theme was that coping with the bureaucracy and expenses that are necessary to set up any support or service for DiDIY as hypothesized in this deliverable (from bringing DiDIY to schools to digital manufacturing training for factory workers, or renting equipment to artisans) is beyond the capabilities of most fablabs. That in itself is not a surprise, but equally recurring was the comment that that excessive load is the same that is equally excessive "*for every other small business, from hairdressers to plumbers, just more unpredictable*".

2.11.2 Existing business and innovation models

In a society that has fully embraced DiDIY, innovation, creativity and any business model that is still built on them, but is not dependent on monopolies and artificial scarcity, have good chances to

73 http://www.didiy.eu/blogs/learning-cuban-technological-disobedience.
74 Especially, but not only, in the course of our "DiDIY minitours" introduced later in this document.

survive, if not to prosper. DiDIY constitutes a much bigger risk, instead, for artists, designers and companies that still pursue, or need, the same strategies.

2.11.3 Separation between (mass) producers and customers

DiDIY may create problems to (many) existing businesses which are already struggling with economics downturns, globalization and similar concerns, but that may not be the main issue. The core of the matter is that many official structures of current society are organized around a clear-cut separation between producers and consumers. Goods and services (including those provided by the public sector!) are supposed to be mass-produced by professional, full time manufacturers or providers. Consumers are supposed to only buy finished products. Laws, liability, insurance policies, environmental regulations, codes of conducts and whole service industries, starting from advertising, are all based on this rigid separation. The more the practice of DiDIY increases, the more that separation, and all the structures and procedures built to maintain it, are weakened.

2.11.4 Rigidity, and scope, of laws and regulations

DiDIY questions not just the basic assumptions behind many current laws and regulations, by bringing changes that laws cannot ignore. It also questions the very way in which many of those rules are structured. Contemporary society often regulates what it perceives as feasible, safe, secure and reliable by setting inside the rules many detailed, but binary, “allowed/forbidden” thresholds about the (fuzzy) phenomena that are the objects of those same rules. Besides, “State law wants to focus on individual property rights, market exchange and state regulatory authority”[75].

DiDIY, instead, is a really fuzzy social phenomenon[76] which presents many intermediate cases, in all sectors where it can be practised. In addition to this, its subjects are almost always individuals who want and can act in complete autonomy, or groups with fluid, informal and dynamic internal rules.

In some cases, adequating laws to deal with DiDIY may be as simple (relatively speaking...) as setting new conventions about where to set the thresholds. In others, the already ongoing changes created, or enhanced, by DiDIY may lead to so radically different scenarios that new decision criteria should be identified and proposed for their social agreement.

2.11.5 Ethic values and safety

DiDIY greatly increases the concrete opportunities for everybody to produce or misuse, even involuntarily, every kind of physical objects. DiDIY, that is, makes it easier to produce or misuse things that, unlike, e.g., software, may directly, physically hurt others, or violate their rights in ways not possible otherwise (e.g., fabricating keys to enter somebody’s home, or using drones to spy on him).

In a society where DiDIY is really, practically accessible to everybody, these opportunities may invalidate altogether some basic agreements and values, like the foundations on which gun control or IP stand today). Eventually, a situation like this can force society to redefine what is right and what is wrong, and consequently to redesign laws and other norms, rather than just “upgrading” them with new thresholds or specific cases.

75 http://www.didiy.eu/blogs/commons-law-perspective-open-hardware-and-digital-diy.
76 http://www.didiy.eu/blogs/structural-view-ethical-non-neutrality-DiDIY.

2.11.6 Personal responsibility

Many DiDIY activities produce objects whose designs not only cannot be legally owned by the DiDIYer who produced them, but may also be changed, and reused in uncontrollable ways, by many more people, without any bureaucracy and without infringing any law. This brings, among other things, more freedom to produce what one really needs, more opportunities to cooperate on social development, effective education or reducing all kinds of waste.

At the same time, this situation makes it much more difficult to precisely attribute, or share, well defined responsibilities when something goes wrong. Therefore, even if only a part of society actively engages in it, a really widespread presence DiDIY must be accepted by society as a whole. Having DiDIY always around, as just one part of ordinary life, implies that every individual accepts more individual responsibility for their actions, and maybe less protection from the action of others (e.g., less product liability than today) than what there would be in a society based on centralized, and strictly controlled mass production.

3. DiDIY synergies

The analyses summarised in this deliverable, together with many other activities and results of the first two years of the Project, confirm an assumption made in its original proposal: “The positive aspects of DiDIY can bring widespread, long term advantage to society only if as many citizens as possible, from today’s students to displaced workers, know at least its real, main general characteristics and potential.” In addition to this, it is evident that wide adoption of DiDIY forces society to update several laws, policies and regulations. Some practical guidelines on how to undertake this work will be provided at the end of the project. For the moment, as preliminary work for those guidelines but also in order to get feedback, here we define and explain:

- the main stakeholders who should realize DiDIY-related synergies, that is work together towards the educational and “rule making” goals just mentioned;
- the main areas in which that work should happen.

3.1 Main stakeholders

A *whole* society cannot move towards DiDIY without the help of those who are already DiDIYers today. DiDIYers, however, are often, almost by definition, focused on self-sufficiency, independence from institutions and actually making things to solve concrete and present problems.

Therefore, at least in theory, another DiDIY-related risk not mentioned so far is that not enough DiDIYers find interest in the long-term activities mentioned here. It is crucial, instead, that the most active and expert DiDIYers including, but not limited to, managers and regular members of fablabs and makerspaces across Europe, take an active role in these activities, since the beginning.

Of course, besides DiDIYers and law or policy makers, other stakeholders should participate actively to the same discussions. From our research so far, the ones who should surely participate (but by no means the only ones!) are “Intellectual Property” advocates and representatives of: teachers, trade unions, local administrators and NGOs working on environmental and social development issues.

Another category that should be involved is that of doctors and healthcare providers. Direct cooperation between DiDIYers and these professionals or organizations, in fact, already provide great examples of the synergies, and in general of a collaborative innovation model. The reasons are that this kind of DiDIY requires much more care and commitment than others, because it has immediate and deep impacts on the health, and often the quality and duration of life of human beings. Besides, it produces devices that DiDIYers cannot design or use alone, but only through strict interaction with specialists who are bound by rightly severe ethical and professional rules. This is why the ways of working in healthcare-related DiDIY should be studied, and when applicable reused together, by DiDIYers and many other stakeholders, from teachers to artisans and professionals in all sectors of society.

3.2 Basic DiDIY knowledge

In accordance with the initial hypotheses of the whole DiDIY project, and of this deliverable, we argue that every citizen should have “basic DiDIY knowledge”. Its main characteristic is perhaps the fact that such knowledge does not need at all to include any technical skills for actually practising DiDIY in person, in any form. The basic DiDIY knowledge that every citizen should

have is not about being able to personally self-build, configure or use any DiDIY machine or component, from Arduino microcontrollers to complete 3D printers or laser cutters. By basic DiDIY knowledge, instead, we mean a general, but correct knowledge and understanding of the risks and opportunities of DiDIY in the several fields discussed here, from ethics to the impacts on jobs and the environment. The first groups to acquire this basic knowledge should be educators, lawmakers and public officials in charge of applying regulations to DiDIY activities.

3.3 Access to DiDIY

From our research so far we can observe that work to grant access to DiDIY is needed, but not necessarily in the sense of, for example, making a priority of setting up a fablab in every school. One kind of access to DiDIY activities that is important to achieve is about equal opportunities. Women, senior citizens, immigrants... are just some of the groups that, so far, have actively participated into the DiDIY/Makers movement less than others.

There are many and complex reasons for this situation, from cultural to economical and structural, for example living in remote areas, or disadvantaged neighbourhoods without efficient public transport to the closest makerspace. Besides, so far the Makers movement has been too often perceived, for whatever reason, as some sort of elite, too focused on satisfying so-called “first world needs”. However, these are are all divides that should be overcome to move to a DiDIY society as outlined in this deliverable.

The other type of access to grant, if DiDIY is to become really commonplace, is the one to what we may call “assisted DiDIY”. Having a 3D printer or any other DiDIY machine in every home is not a realistic goal. Besides, is one that would constitute a great waste of resources, with millions of such machines doing nothing for the most part of the time. Above all, it is a target that is not necessary to achieve, even if the goal is that of a DiDIY society.

In that context, it is much more important to make it possible for makerspaces, fablabs and similar places, to open their doors to everybody who may need DiDIY maybe just once a year, to fabricate just one object, and then go back to their usual life.

Some of these occasional DiDIYers may have no direct access to DiDIY machines, but still have the skills and time to correctly design something from scratch on their computer. At that point, they should only send the corresponding files, via the Internet, to any of the companies that already rent their machines, to perform digital manufacturing on demand. These people, however, are and will almost surely remain a tiny minority of the general population.

There are plenty of people, instead, who may really need, sooner or later, something obtainable only with DiDIY, but will never have the time, technical skills or physical capabilities to do it entirely by themselves (or money to spare for equipment that may not be used any more after the first usage...). These occasional DiDIYers would need direct, face to face assistance from an expert, to design and make something with a 3D printer or CNC mill. Even more frequent would be the cases in which the same people would just outsource the design and fabrication work to real DiDIYers, if it just were affordable. The beneficiaries of this “assisted DiDIY” or “DiDIY-as-a-service” would include, just to make three really broad examples, all relative to real world cases that we met in our “DiDIY Minitours” across Europe[77]:

77 These minitours and the main findings from them are documented in the corresponding section of the DiDIY Project website at the address http://www.didiy.eu/tags/DiDIY-minitour.

- individuals wishing to make a unique birthday gift, or need one out-of-production spare part for their kitchen;
- small businesses that need to make or repair some custom machine for their for-profit, professional activity;
- artisans who need to personally use high-end DiDIY machines on a regular basis for their craft, but only part time, and therefore could not afford to buy, host and maintain the same machines in their official laboratory.

It is hard to deny that, strictly speaking, “assisted DiDIY” or “DiDIY-as-a-service” are contradictions in terms. Still, this is a market, or social need, of remarkable size, and one that could make real DiDIY sustainable.

Today in Europe there already is, at least in major cities, a good number of places and communities that provide personal digital manufacturing services. If they could regularly and openly cater to the needs above, they would also gain more money to support their staff, their core members and their projects. The problem is that, according to current regulations, almost always they can only offer such services to their own regular members, and only for non-profit, recreational use. This excludes, or at least makes it unnecessarily harder to serve, the scenarios above, especially the last two. Access to “assisted DiDIY” like this needs to become much easier to handle.

3.4 Rule making

Rules need to change, or at least to be closely re-analysed and confirmed as adequate to cope with DiDIY, at all levels, from EU directives to national school or professional regulations and city building codes, in order to make DiDIY ubiquitous, and its benefits accessible to every citizen, while taking into account all the risks discussed in this deliverable.

Access and education actions may even happen, and be supported, locally, without any central coordination or “one-size-fits-all” approach. Analysis of existing rules and, when necessary, their upgrade or completion with new ones, instead, must take place at several levels, from the European Parliament down to, at least, regional administrations. That process must also be open from the beginning to all stakeholders, in order to achieve the best compromise among all conflicting interests at stake, and to prevent loopholes.

Today, for example, many fablabs cannot afford certain machines not because of their intrinsic cost, but because it would be too expensive to comply with all the corresponding safety codes, which were written only for full time industrial production of very large quantities of goods. Many fablabs also cannot invite schools to show students the wonders of DiDIY, train workers, or rent their machines to artisans because, under the current rules, getting certification for such activities is too complex or expensive to be worth the effort.

These rules are almost always the same which are a heavy burden also for traditional small businesses. Today, however, fablabs and similar “DiDIY facilitators” find it much harder than other categories to comply with them. In part this happens because the technology still is relatively new, but an important reason is that many public officials who manage certifications and permits know little or nothing about digital fabrication. Therefore, they often tend, in good faith but without an objective need, to err on the safe side when they apply the rules.

This situation must change, but taking care of avoiding dangerous side effect. Opening the doors of fablabs to students and independent workers, for example, would likely be great for both the

education system (if teachers are prepared for it) and the general economy. However, it should not happen in ways that make it easier to disguise unreported employment or child labor as DiDIY training or education in a fablab.

3.5 Synergy examples

A comprehensive set of synergic actions and proposals will be included in the final guidelines of the DiDIY project, in June 2017, of which this deliverable is a preparatory step. For a better understanding of the deliverable, and in order to collect feedback for the guidelines, we provide here a *draft*, partial list of those actions and proposals, to be validated later on in the Project:

1. define the contents, and provide the related funding, for *local* basic DiDIY knowledge training for teachers and public officials;
2. organize local events (fairs, contests, workshops…) with the specific goal of getting the same teachers and officials interested in basic DiDIY knowledge, and in the above training;
3. define realistic building codes and safety requirements for fablab spaces, that guarantee safe operating conditions, but without imposing the same constraints that would be necessary only in very large factories, operating full time;
4. define rules and codes of conduct that allow DiDIYers, after proper training and liability releases, to perform certain operations in a fablab even when its official manager, or her delegates, are not present (this would allow fablabs to stay open to rent their machines even 24/7, and would therefore be more economically sustainable);
5. propose and test practical rules and procedures to make it legal, and easier, in fablabs but also in schools, the use of machines that are self-built, or lack user interface or documentation in the local language;
6. propose laws, and rules for industry associations, to support “digital manufacturing” retraining of workers, both in the forms of incentive for companies to send their workers, and in licensing procedures for the fablabs that would host the training;
7. define conditions under which it would be legal for artisans to rent space and machines in a fablab to perform part of their for-profit activities there (or to send their employees to do the same);
8. define control and (self) certification procedures that would allow professionals and small businesses (dentists, architects, plumbers, chefs, food retailers, farmers, etc) to use DiDIY to build the tools they need for their work;
9. study insurance policies for all the scenarios above;
10. propose fiscal incentives for fablabs and NGOs that work together to use DiDIY on social/community development programs;
11. propose fiscal incentives for fablabs and NGOs that work together to teach DiDIY to women, senior citizens, immigrants and other disadvantaged groups;
12. translate in all European languages selected reports an other deliverables of the DiDIY project, to facilitate the dissemination of its results.

3.6 Towards the final guidelines: the DiDIY patterns wiki

In depth, collaborative, open analysis of existing rules, and, when necessary, preparation of concrete proposals of laws and regulations that handle DiDIY as anticipated in this deliverable should start as soon as possible. The DiDIY Project has already set up, at the URL http://didiy.referata.com, a public repository for "policy patterns" that should be used also for this purpose. Policy patterns are short, structured descriptions (along with other helpful information) of a solution to a particular problem of the type described here. Eventually, the patterns will form a collection of possible solutions (that is, not formal, rigid recommendations) that others can adopt to their own needs and situation. All DiDIY stakeholders are welcome to add their proposed patterns to the wiki, or refine existing patterns.

4. DiDIY Open Educational Resources

In the course of its activity, the DiDIY Project has already produced, and made available as Open Educational Resources (OERs), several materials. As of December 31st, 2016, they include several workshops by POLIMI and UOW, an experimental "Introduction to Digital DIY" course[78] and most of the videos published in the official DiDIY video channel[79]. These and other resources from the DiDIY team are and will be collected, for the duration of the project, in a dedicated page on the DiDIY website[80]. The same page includes, in a separate section, DiDIY OER resources from third partners.

In addition to these resources, the guidelines in the following section are provided as basis for authoring, sharing and usage of more DiDIY OERs and professional training material, both for ordinary schools and for adult/lifelong learning programs.

4.1 DiDIY OER guidelines

These guidelines are meant for educational content aimed at providing, both in stand-alone courses or courseware, and as part of professional training what has been defined here as "basic DiDIY knowledge".

From the licensing and technical points of views, all the material should be released under a Creative Commons attribution-sharealike license, and in editable, truly open file formats. By "open" we mean formats that are fully usable on any operating system, and whose complete specifications are fully published, and reusable by everyone without paying royalties or any other constraints. Example of these formats for text are OpenDocument (.odt extension), Markdown (.md), XML and plain text. The content of these OERs should include, as a minimum, introductions to the following topics:

1. definition of copyright, patents, trademarks;
2. fair use and other exemptions to copyright that apply to DiDIY;
3. importance of proper licensing and documentation of everything produced with DiDIY and shared with others *(*sharing a design by just "abandoning" on some web server some undocumented source files, without any explicit license, would only result in orphan works (license-wise) that are also very difficult to reuse, because they lack explanations);
4. definition and overview of the several risks and opportunities presented in section 3 of this deliverable;
5. introduction to the concepts of Free/Open Source Software, Open Hardware, Creative Commons and Copyleft;
6. description of *all* the main DiDIY technologies, not just 3D printing, e.g., laser cutting, CNC milling, microelectronics;
7. real world examples of how DiDIY is not limited to "high-tech" applications, but can and is already used;
8. description of the main DiDIY online communities.

78 http://www.didiy.eu/digital-diy-course-introduction.
79 http://vimeo.com/DiDIY.
80 http://www.didiy.eu/open-educational-resources.