-Exploring the Emergent Open Manufacturing Industry-

Harnessing the power of Digital Social Platforms to shake up makers and manufacturing entrepreneurs towards a European Open Manufacturing ecosystem

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DISCLAMER

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EXECUTIVE SUMMARY

The aim of this white paper v1.0 is to offer a comprehensive vision of two paradigms of outmost importance for the future of European Manufacturing; Industry 4.0 and maker movement.

These two trends might be disparate but at the same time as we show in this document, there are clear synergies between them that can help to meet the challenges that the digitization of European industry can create in SME´s, value chains, workforce and society. That is why so important to help to create alternative infrastructures that will gather makers and manufacturers for creating an open and collaborative innovation that can thrive to new business opportunities and mitigate the negative externalities of technological innovations.

This document is organized around three thematic issues that correspond to the main building blocks of the OPENMAKER project; Industry 4.0, the maker movement and the combination of them in the development of an ecosystem of open innovation throughout the development of LES.

We start identifying the main challenges that the European industry is facing nowadays in the transition towards the Factory of the Future. In the second section, we explain the origins of the maker movement and what are the main motivations and values that lie in this grassroots movement that is quickly spreading worldwide. Finally, we highlight how the OPENMAKER project provides an alternative ecosystem to communities that want to be engaged in the opportunities that open design and open manufacturing establish throughout entrepreneurial values, business models, production processes and practices.

In the first version of this white paper we would like to set the ground for a public consultation of how these ideas are flourishing in different ecosystems and how can be aided by policy makers. The spirit of the document lies in how supporting the maker movement can help to favor the transformation of the European industry towards the embracement of an open innovation paradigm supported by open source technologies, social production and network based organizations that can help in the digitization challenge.

To achieve that objective a preliminary set of recommendations have also been developed at the end of the document. These guidelines are;

- **To support makers in connecting with manufacturers, artists, researchers and policymakers**.
- **To make EU funding more accessible for makers and manufacturers**.
- **To initiate dedicated initiatives for makers**.
- **Encourage creativity and entrepreneurship for young people**.

GLOSSARY OF TERMS

AI	Artificial Intelligence
CBA	Center for Bits and Atoms
CNC	Computer Numerical Control
DIY	Do-It-Yourself
EFFRA	European Factories of the Future Research Association
FLOSS	Free Libre Open Source Software
ICT	Information and Communication Technologies
ID	Industrial Districts
IoT	Internet of Things
LES	Local Enabling Space
MIT	Massachusetts Institute of Technology
NSF	National Science Foundation
P2P	Peer to Peer
PSS	Pilot Supporting Scheme
R&D	Research and Development
SME	Small and Medium Enterprises
STEM	Science Technology Engineering Mathematics

OpenMaker

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"You do have to try, learn, and improve. You do have to put yourself out there and risk failure. But in this new world, you don't have to go bankrupt if you fail because you can fail small. You can innovate as a hobby. Imagine that: a nation of innovation hobbyists working to make their lives more meaningful and the world a better place. Welcome to the maker revolution"

Mark Hatch,

-The Maker Movement Manifesto-

1. INTRODUCTION

What will the future of manufacturing in Europe be like? Will factories all over Europe turn into something completely new? Will manufacturing return to be central to European cities? Automatized factories will erase most of industry jobs? Are Makerspaces a possible player to re-connect society, global innovation and local manufacturing? Will Makerspaces be the factories of the future? Are makers preparing the new breed of digital workforce?

While nobody really knows what the European manufacturing sector will look like in the next 10 years, some trends are starting to emerge. The rise of technological innovations such as Robotics, Cyber-Physical Systems, 3D Printing, Artificial Intelligence and many others as well as the increasing competitiveness of emerging countries are pushing a major modernization of European factories. This transformation is being pushed by the digitization of European industry for embracing what has been coined as Industry 4.0.

The introduction of digital innovations in the factory and its application to production processes is not merely a process of technology acquisition; it demands a total rethinking of the organization, its position in the value chain and the value proposal itself. We are at the midst of a new industrial revolution that will create new business opportunities but at the same time it will create several challenges that policy makers and regulators will have to tackle to prevent the side effects of innovation that will affect to society.

In this context, we would like to propose some provoking ideas about what could work and what could go wrong in the smart-city scenario of the next decades. The aim of this white paper is to provide a number of insights from two different perspectives that at the forefront can resemble significantly different but at the same time share some features that we believe that will come together at some point and will play a critical role in the near future.

We build on this work in a comprehensive desk research, an international survey oriented to the communities involved as well as an ethnography research that has included several events that our LES have hosted or promoted with different stakeholders, the numerous interviews that have been delivered throughout the project (around 100 at the time that this document is being written)[1] to different collectivities such as manufacturers, makers, administrations, CSO´s, etc., the number of projects that have been funded throughout the PSS scheme and other peripheral actions that have been carried out of the project.

We argue that makers and manufacturers can benefit from each other in this transition to the automated factory if suitable infrastructures are provided from the policy arena to establish permanent partnerships that can thrive into sustainable and socially oriented innovations that can be beneficial to a large part of society.

[1] It is expected that at the end of the project 240 interviews will be delivered.

2. INDUSTRY 4.0 IN EUROPE: A CHALLENGING TRANSITION

Europe has always boasted of a strong manufacturing sector: in 2014, manufacturing represented around 16% of the EU GDP, more than 80% of EU total exports, 2 million companies, 60% productivity growth, 80% of private Research & Development expenditure, and employed 30 million people[2]. However, the financial crisis has heavily hit the sector, combining its negative effect with on-going globalization and technological innovation negative externalities[3]. Together, these factors have led to the loss of over 3.8 million jobs, mainly amongst low-skilled and medium-skilled workers.

The data provide evidence that Europe is currently facing not only an economic and financial crisis, but also an industrial one. Despite this situation, manufacturing will continue to be a major source of employment in 2025 in Europe (EU Skills Panorama, 2014).

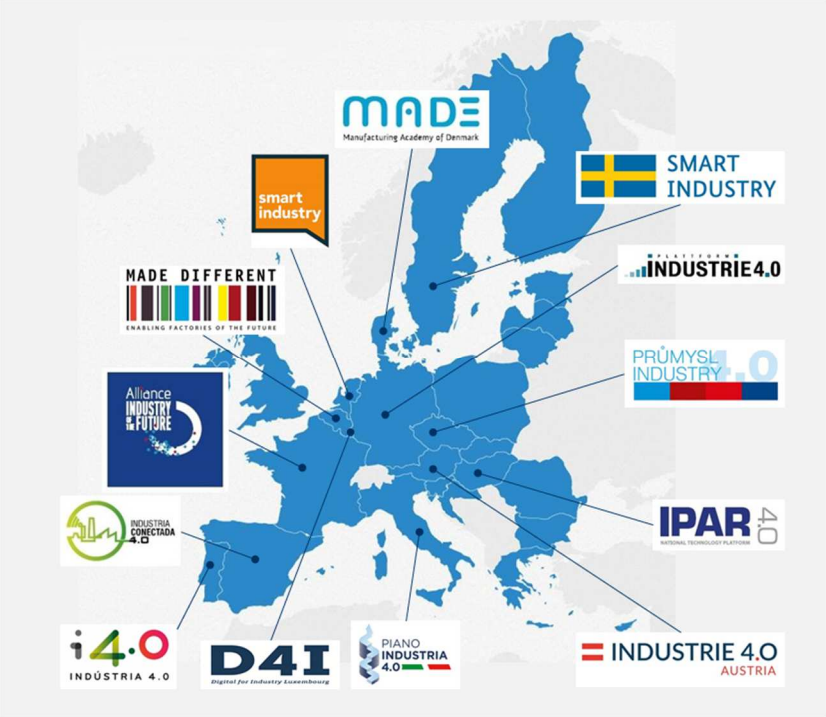

Figure 1. Map of different European initiatives around Industry 4.0
Source: European Commission

At the same time, some authors have argued that we are entering a new industrial revolution (Brynjolfsson & McAfee, 2014; Schwab, 2016) where the concept of the factory itself has to be revisited. Smart Industry or Industry 4.0 (Davies, 2015) are some of the labels that are branding a much more automatized, digitized and flexible production ecosystem concept. The term Industry 4.0 was originally coined in 2011 by the German government to support local manufacturing and push forward the digitization of their production processes (Verniere, Van der Straeten, Torfs, Venderlinden, & Van den Kerkhof, 2017). Between 2011 and 2015, different definitions emerged such as Smart factories, Industrial Internet of Things, Smart industry, or Advanced manufacturing. Nowadays in Europe, Industry 4.0 has become the common term to define the *"group of rapid transformations in the design, manufacture, operation and service of manufacturing systems and products" (Davies, 2015)*

[2] See Commission Task Force on Advanced Manufacturing for Clean Production (2014)

[3] While Frey-Osborne, (2013) identifies that 47% of current jobs – including accountancy, legal work and technical writing - risk being completely automated in twenty years, it is already apparent that the "sharing economy" and the "on-demand economy" are facilitating nonstandard employment and subcontracting, reducing substantially workers' protection and, therefore, prospective retirement incomes. On this topic, and on the impact of globalization on the manufacturing sector, see also Center for American Progress, 2015.

This digital-driven revolution aims to reshape all manufacturing processes and operations, and it is backed up by a number of European initiatives like "Factories of the Future" Public-Private Partnership[4] program, where heavy investment is fueled and more than 2.000 organizations have been involved through 240 different projects (Pazin, 2017), with the overall goal of boosting the transition to the 4.0 Industry paradigm. Almost every country in Europe have adopted a particular strategy towards this change of paradigm (see figure 1), aligning or fostering national initiatives to the European Commission strategy. It is expected that in the near future this push for the digitization of industry will continue with some flagship initiatives that will help companies, traditional manufacturers and SMEs from different member states to pursue the overarching objective of digitizing traditional industry. This is the rationale behind some of the declarations made by several EC representatives such as Andrus Ansip, Vice-President of the European Commission for the Digital Single Market who recently stated:

"I congratulate the Member States which have already started their national political initiatives, committing significant financial and organizational resources to digitizing European industry. I warmly welcome the newcomers and encourage other countries to join. The European platform of national initiatives is an example of a collaborative and cohesive European Union. This is a strong effort at European level, but it will produce results only if Member States do their part and support industry and innovation communities in their regions which drive digital transformation."[5]

As the Vice-President acknowledges, this digitization processes will only be successful if the different member states commit themselves to this shared objective and establish national measures and programs that can be endorsed by different kinds of companies, entrepreneurs, stakeholders and society as a whole. In this context, it is worth highlighting that digitization is an ongoing and open-ended process where different economic, legal, social and cultural aspects can act either as a driver or a barrier to innovation. This new model of factory will be powered by disruptive technologies like Big Data, Robotics, Cybersecurity, Internet of Things (IoT), artificial intelligence (AI), Cyber-physical systems or Additive Manufacturing.

These new technologies have in common a particular need; **a new kind of skilled employees trained to operate in the new technological revolution that is about to start.** This is particularly tricky in Europe, where some reports have shown that around 900.000 jobs could be demanded in the next few? years (Gareis, K., Hüsing, T., Birov, S., Bludova, I., Schulz, C., & Korte, 2014), with specific profiles that are currently non-existing. That is why the transition to Industry 4.0, while shaping new horizons for a more efficient, innovative, agile and flexible manufacturing sector, also creates new challenges for the workforce already employed in this sector and future professionals. The importance of manufacturing for innovation in Europe is essential as the factory is the place where new ideas are turned into tangible products (Sol, 2015). Prototypes can be industrialized and machinery is available for putting new ideas into practice, but more important, non-technological innovations like organizational or marketing innovations have been launched in factories. Taking into account that more than 80% of EU exports are coming from manufactured goods (European

[4] More info about this initiative at this link https://ec.europa.eu/research/industrial_technologies/factories-of-the-future_en.html
[5] Extracted from https://ec.europa.eu/digital-single-market/en/news/european-countries-join-forces-digitise-industry

Commission, 2013) the relevance of creating a new innovation ecosystem in traditional industry is of outmost importance for Europe.

2.1. DIGITIZATION, CONNECTIVITY & OPEN VALUE CHAINS

Possibly, the greatest challenge that the European manufacturing sector is facing nowadays is what is commonly known as digitization. The integration of information and communications technology (ICT) to manufacturing capabilities (machinery, connectivity, etc.) does not merely depend on the acquisition of specific technologies. Rather, it is a more complex and challenging transformation that demands to rethink all components, structures and processes that are being carried out in a factory.

According to Željko Pazin, president of European Factories of the Future Research Association (EFFRA*); "digitization means more than the installation of new ICT or high-speed connectivity. It is a complete transformation of where, how and why we manufacture. It is shaping the factory floor, products, the skills of workers and integrating services and supply chains".* (Pazin, 2017)

Europe holds a strong position in high-tech, with some of the most important research and development (R&D) centers developing substantial digital technologies that can be embraced by different industries. But at the same time, Europe is also facing a growing competition from different parts of the world (especially Asia) in this domain. Traditional companies are awakening to tech, new digital hubs are emerging in the European landscape and deep tech is been diversified, while member states struggle with heavy investment in late stages of the process (like commercialization stage) which can mean a significant obstacle in this transition[6]. Large investments are needed to acquire technologies that can help to monitor processes, connect systems and control production.

These investments can be overwhelming for SMEs that may lack the capital needed. To tackle the challenge small companies will have to cooperate in order to share resources and create open value chains (IEC, 2015) able to mitigate such shortcomings. The demand for personalized products will create shorter product lifecycles and will demand more flexible, agile and resilient systems. Although bigger companies may have easier access to funding, it is likely that they will face the same challenges that will boost a collaborative corporate culture to remain competitive as they are highly interconnected with SME´s in their value chains[7].

[6] See for instance the report "State of the European tech" at http://www.atomico.com/news/the-state-of-european-tech-2016

[7] Major European manufacturers like Volkswagen have a large list of suppliers (more than 40.000) that are already coordinated in digital platforms. See for instance https://www.volkswagen-media-services.com/en/detailpage/-/detail/Volkswagen-Group-expands-digital-supply-chain/view/4940553/4277f85fa0fe74e68f860d037e02125e?p_p_auth=fqbWuvt1

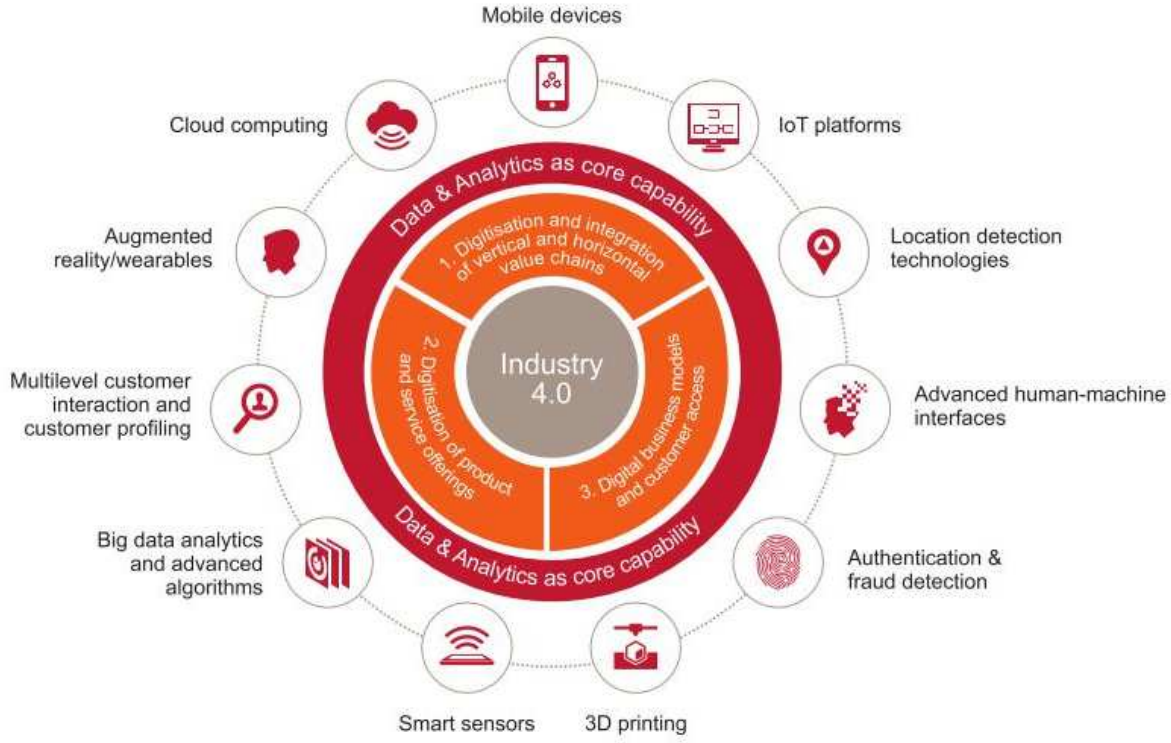

Figure 2. Digital technologies contributing to an Industry 4.0 Framework
Extracted from (Verniere et al., 2017)

In addition, another important challenge is the large disparities in digitization occurring between the different regions implementing such strategies and initiatives. The asymmetries that can appear in the digitization of different industries across Europe (bandwidth connections, ICT equipment, etc.) could be an important barrier to achieve a flexible, agile and connected ecosystem that can pave the way to the desired transition towards a digitized economy. These inequalities between different member states can hinder the innovation potential of Europe as a whole and this is something that has to be fixed before it is too late. This is probably one of the great challenges as the future of industry will be digital (European Commission, 2017) however historically digital technologies tend to create or enhance disparities and economic divides (DiMaggio & Hargittai, 2001). In this light, European policy makers will have to draw special attention on how to embed inclusion within a digitized industry and, by extension, society.

2.2. DIGITAL SKILLS & WORKFORCE

When we look back at the main industrial revolutions of modern times, the role of technology is usually stressed to comprehend how different social structures, processes and behaviors have changed. Phenomena of deskilling and reskilling have happened in previous transformations of productive structures and, predictably, Industry 4.0 will not be an exception as it is mainly driven by the Internet of Things. Manufacturing has constantly evolved from dusk, dull and duty manual procedures to advanced machinery able to ensure a maximum degree of efficiency. This trend has been one of the reasons for erasing a considerable amount of low-skilled jobs out of the industry

and this will continue in the future as automatization and AI drive the current technological revolution.

Despite low-skilled jobs are at great risk of disappearing, there will be a great demand of high-skilled profiles, since the new paradigm will require a closer collaboration between humans and machines. New technologies like AI, robotics and cyber-physical systems will improve the autonomy of employees in factories but they will also demand advanced digital skills. This is probably one of the most important challenges for the European industry, expected to experience a major shortage of ICT professionals by 2020. In fact, it is foreseen that in the future 9 of 10 jobs will require digital skills and Europe is not adequately prepared for this shift since 44% of Europeans do not have basic digital skills[8]. This is one of the hot topics in the European policy agenda, with some important initiatives like The Digital Skills and Jobs Coalition[9].

Another important matter to highlight concerns the privacy issues that will be risen with the introduction of "monitoring technologies". This kind of machinery will provide insights of production processes and it will monitor different tools that are part of the factory as well as humans to understand behaviors, routines, etc. In this regard, we envision future conflicts since this will generate sensitive data that will need to be managed, controlled and ultimately secured.

2.3. DATA & STANDARDS

When we talk about digitization in industry we usually think about reinventing production processes, rethinking business models, reorganize operational structures and of course collecting, storing, analyzing, formatting, using and reprocessing data.

In the digital economy, data are indeed the new oil, and the transition towards data-driven business models is one of the more radical changes that digitization imposes on all kinds of organizations. Platform economy (Srnicek, 2017) has shown us how different products can be transformed into services technologically facilitated by digital platforms, and it is possible that manufacturing will follow this path in the near future. Both to rediscover production processes, and to allow the exchange of knowledge between different systems and platforms outside the factories, which can be transformed into new services, or joint ventures with suppliers or other stakeholders of these open value chains that are about to emerge.

In this scenario, we must pay attention to the large amounts of data that will be generated in these industrial environments which will create new needs and requirements for data treatment. Concerns about who owns data and how the latter are shared for generating new business opportunities will be common. For instance, car manufacturers might evolve to open models that are used by aircraft manufacturers to upgrade their practices in response to the challenges created by self-driving cars. At the same time, new European regulations will be needed to balance trust and data protection (Davies, 2015).

Finally, there is also a clear need to work on standardization to provide a set of rules and protocols that can be commonly embraced by different countries and sectors, thus ensuring reliable and accountable operational frameworks. Standards are the tools that guarantee quality processes and enable the connection of different technologies to procedures that are carried out in any given manufacturing industry. Standards are a major force of innovation (Russell, 2014) but it takes time

[8] Digital Single Market has published a factsheet stressing this issue. See https://ec.europa.eu/digital-single-market/en/news/digital-skills-gap-europe

[9] See https://ec.europa.eu/digital-single-market/en/digital-skills-jobs-coalition

and efforts to develop them and achieve a shared vision between companies, regulators, academia and other stakeholders. That is why there is a strong need to promote expert groups and task forces that can agree on formats, protocols and interfaces enabling interoperability over European industry.

3. THE MAKER MOVEMENT

"Maker movement" is the expression coined by Dale Dougherty (2012) to indicate people that engage passionately with new technologies such digital fabrication tools, IoT, computing design, etc. and are keen on creating new objects or developing cutting-edge projects. Other authors have also referred to this global phenomenon as "maker culture" (Anderson, 2012; Silvia Lindtner & Li, 2012; Adrian Smith, 2017) in order to stress the values, ethos and behaviors that are behind this new philosophy of engagement with technology in an environment of tinkering, prototyping and experimentation.

In this section, we will take a look at the origins of this movement and the main characteristics that have encouraged its popularity and diffusion all over the world. We will also pay attention to the potential that this creative approach to technology can have in different sectors and especially for developing ecosystems that can foster grassroots entrepreneurship and innovation in society. Last, we will also highlight some of the challenges that lie ahead of this emerging phenomenon.

3.1. ORIGINS

The roots of the "maker movement" can be found in the expiration of several patents in the field of digital fabrication & ICT and its subsequent popularization. Different kinds of technologies such as microelectronics, 3D printing, 3D design, etc. in combination with a regime of social production (P2P) (Benkler, 2006) and an emphasis on informal learning (online and off-line) (Tabarés-Gutiérrez, 2016) have provided new approaches to develop technological innovations that rely on a model that differs from the classical linear one (Lundvall, 1992).
The maker movement's origins can be traced back to the 1920´s with the phenomenon of Pirate radio broadcasting (Haring, 2008) and it is closely related to the Do It Yourself (DIY) philosophy (Sun, Lindtner, Ding, Lu, & Gu, 2015) that has been present in society at least since the 70´s (Kuznetsov & Paulos, 2010) and that experienced great popularity in the '80s, '90s (Atkinson, 2006) and present times (Fox, 2014). Understanding DIY is not easy as it encompasses design, art and crafting, whose boundaries are blurred (Atkinson, 2006). In this regard, a useful definition is provided by Kuznetsov & Paulos;

> *"We define DIY as any creation, modification or repair of objects without the aid of paid professionals"* (Kuznetsov & Paulos, 2010).

This definition contributes to stress the altruism and amateurism components that are at the core of the "maker movement" (Dougherty, 2012)and embedded in the "hacker ethic" (Himanen, 2002). These two philosophies gravitate around the passion for technology that characterized the American counterculture of the twentieth century, a passion shared by the first pioneers of personal computing, the Internet and the Web (Barbrook & Cameron, 1996) towards the generation of social change and create a better world throughout the use of technology. This is the primitive spirit of the hacker ethic that is also embedded in the maker movement; using technology for promoting change and the good of society. We can argue that this new wave of engagement with technology is strongly shaped by the easy access to "open hardware"; technologies that share an open design that allow to develop artifacts and technological objects that can satisfy specific needs that are not

met by mass production. This provides room for creating alternative paths for R&D and for creating technology that can meet demands from excluded collectivities or with under-representation in society. Silvia Lindtner stresses this difference of the maker culture regarding the hacker ethic (Himanen, 2002) and its emphasis on coding;

> *"Today, we find ourselves in the middle of a new hacker culture (or 'maker culture') that both harkens back to this model of technology production as individual empowerment and departs from it in significant ways. This contemporary maker culture is concerned not only with open Internet technology and digital things, but also with physical things such as hardware designs, sensors, and networking devices that bridge the digital and physical worlds. While the earlier movement was concerned with the workings of software code and the workings of the Internet, this contemporary maker movement is concerned with hardware designs and the workings of the Internet of Things.* (S. Lindtner, 2014)

As Lindtner argues, the maker culture is powered by individuals that play and tinker with technology (S. Lindtner, 2015), just as hackers do, but their scope is much broader because these new technologies allow to merge physical and virtual worlds throughout artifacts without a proprietary design (Gershenfeld, 2005). The rising of different open source initiatives like Arduino (Dafermos, 2015), Raspberry Pi or RepRap (Kostakis & Papachristou, 2014) have made possible the development of different low-cost innovations. These open source platforms have allowed to prototype and create small batches that can work with specific requirements, and that can be improved without the need of manufacturing a large set of products. The disruption of personal fabrication (Ferger et al., 2013; Lipson & Kurman, 2010; Mota, 2011) and low-cost micro-electronics have drawn a lot of attention from citizens, who feel empowered and engaged in the Hackerspaces, Makerspaces and Fab Labs in cities all over the world. In these spaces, we can find 3D printers, 3D scanners, welding kits, laser cutters, computer numerical control (CNC) machines and other tools that help to carry out collaborative projects of digital fabrication that promote citizen engagement with technology as well as different events, trainings and activities aimed at fostering citizen empowerment (A Smith, Hielscher, Dickel, Söderberg, & Oost, 2013). Moreover, the popularity of platforms like Thingiverse[10] and many others that work as "knowledge artifacts" (Locoro, Cabitza, & Mari, 2017), make possible that different users around the world can upload, document, share, discuss, learn and download different projects using the Web as infrastructure.

Due to the variety and impact of the different projects developed in these virtual & physical ecosystems, some authors have started to speak about a "new industrial revolution" (Anderson, 2012; The Economist, 2012) or a "democratization of fabrication" (Mota, 2011). Although these spaces and collectives provide opportunities for reconnecting western societies with manufacturing activities in a more sustainable way (Scholz, 2012), promoting entrepreneurship and innovation in society (A Smith et al., 2013); we cannot forget that the principal barriers to engage with these technologies do not lie in the means of production but in the means of accessing the knowledge that have been increasingly fragmented (Locoro et al., 2017).

[10] Thingiverse (http://www.thingiverse.com) is a platform where different 3d designs can be found for free. The site has been greatly influenced by "The Whole Earth Catalog", an important American counterculture magazine and product catalog published by Stewart Brand.

3.2. NETWORKS & LABS

The spreading of the maker movement across the globe has been possible thanks to network effects (Farrell & Klemperer, 2007; Klemperer, 2006) that spread through Internet and different on-line communities (Rheingold, 1996, 2007), as well as to the rise of different spaces that have made possible to engage with non-proprietary technologies through different activities like collaborative projects, workshops, seminars, etc. (Niaros, Kostakis, & Drechsler, 2017). This is the case of Media Labs, Fab Labs, Makerspaces, Hackerspaces and other urban labs. Some of them belong to more formal networks like the Fab Lab Network, set up in 2000 by Neil Gershenfeld that was at that time the Director of the Center for Bits and Atoms (CBA) of the Massachusetts Institute of Technology (MIT). The CBA received funding from the National Science Foundation (NSF) for setting up a Lab with different machines that allow "to make (almost) everything" in collaboration with the Grassroots Invention Group (Gershenfeld, 2005). After the foundation of this first Fab Lab others follow in India, Norway, etc. In addition, Neil started delivering training materials to allow anyone across the globe to use the machines and at the same time understand what open hardware and digital fabrication is. These materials will be later part of what today is known as "Fab Academy"; a very successful e-learning program that teaches and certify thousands of people in different labs around the world[11].

Other initiatives like Makerspaces or Hakerspaces have been growing at a fast pace during the last years despite the specific requirements imposed by the development of a formal network[12]. Indeed, these spaces are identifiable not only by machines and tools but also by the different set of activities, events and workshops run. In all of them, the use of open hardware, Free Libre Open Source Software (FLOSS) and collaborative learning methodologies are encouraged by their members.
The spread of these labs over cities have been highly remarkable and we can currently find around 1.150 active Fab Labs[13] and 1.355 Makerspaces[14].

Another interesting initiative but with an industrial approach that has been really popular in the US is TechShop. This network of membership-based DIY workshops and fabrication studios inaugurated 10 spaces in the US and 3 more at international level[15]. TechShop provides access to its users to a more advanced and industrial equipment that it is not usually found in other regular spaces like MakerSpaces or Fablab. It is managed like a business and there are different subscriptions (monthly, weekly and students pass) that clients can contract, offering different training materials, activities and workshops to help users to command their equipment. TechShop holds strong partnerships and sponsorships within the industry like Ford & Autodesk in US, Samsung & Fujitsu in Japan or Leroy Merlin in France. These connections with big companies help entrepreneurs to scale up their ideas into industrial settings. Unfortunately, at the time this report has been written, TechShop has declared bankruptcy and the company has closed all the 10 US spaces (international spaces have

[11] More information about the program can be accessed throughout the website http://fabacademy.org/
[12] For instance, to be part of the Fab Lab network a specific set of machines is compulsory.
[13] In the platform Fablabs.io there is an updated list that can be checked https://www.fablabs.io/labs
[14] In the Hackerspaces wiki we can find check the figure but it is not updated as it is the previous one. https://wiki.hackerspaces.org/List_of_Hacker_Spaces
[15] Tokyo, Abu Dhabi and Paris & Lille.

not been affected by this) without formal warning[16]. This sad episode reflects the imperative look for sustainable business models that all kinds of spaces that are engaged in the maker movement must deal with.

Dedicated events have played a key role in the growth and popularization of the maker movement. The Maker Faire, an important event that takes place in different locations around the world, helps to connect these spaces, collectives and individuals, and is one of the reference events widely known by the general public. This event was firstly pushed in 2006 by Make Magazine (Sivek, 2011) to celebrate the maker movement and giving visibility to all the projects that have been developed by the do-it-yourself (DIY) philosophy in garages or urban labs. According to its creators the "*Maker Faire is the Greatest Show (and Tell) on Earth—a family-friendly festival of invention, creativity and resourcefulness, and a celebration of the Maker movement*. *Maker movement"*[17].
During the last years, these events have become really popular with a great success of public attendance and media attention.

Figure 3. Maker Faire Bilbao 2017
Source: Own image

Last but not least, there are other networks that have been developed during the last years towards specific interests or emerging issues that have been fostered by different members of these

[16] An explanation of this closing by his CEO, David Woods, can be found at this link; https://makezine.com/2017/11/15/techshop-closes-doors-files-bankruptcy/
[17] A little recap of the history of these events can be found at this website https://makerfaire.com/makerfairehistory/

communities. One of them is "Enabling the Future"[18], an initiative for those interested in 3D printing that want to use this technology to help physically impaired children with open source prosthesis or orthoses that can help them in their daily lives. Another interesting initiative is "Fab City"[19], supported by the Fab Lab Network to develop self-sustainable cities to abandon the industrial paradigm of buying goods and produce waste that is deeply rooted in our current cities. Different stakeholders are part of this initiative, and cities that onboard to the network commit themselves to circular economy approaches that can help them to be self-sustainable in the near future.

3.3. VALUES & ETHOS

The maker movement has a distinct set of values that can be traced back to the DIY spirit emerged in the 60´s due to some initiatives like pirate radio stations and radio amateur pioneers (Haring, 2008) as well as initiatives like the Tech Model Railroad Club (TMRC) of the MIT which can be considered as one of the first organized hacker groups (Levy, 2010). This club is also famous for coining the aphorism *"All information should be free"* which has been one of the most recurrent mantras in later philosophies of technology empowerment. Later in the ´70s with the rise of counterculture (Barbrook & Cameron, 1996) and afterwards with the consolidation of cyberculture (Turner, 2006) we will see how the values that are around the hacker ethic (Himanen, 2002) will be disseminated widely throughout different grassroots movements that are favored by the Internet & the Web and the different networks and platforms that have being established. The maker movement has also inherited these traditions of tinkering, playing and experimenting with technology with the uttermost objective of making the world a better place.

Although we cannot speak about "a unique maker movement" that shares a coherent set of values across the globe - as this phenomenon is both a symptom and an effect of the different transformations that capitalism is facing in different countries towards the knowledge society (Silvia Lindtner, Bardzell, & Bardzell, 2016) -, we can nonetheless state that similarities exist across the various maker collectives worldwide. Indeed, the most prominent values are tightly related to the open source movement and collaboration, creativity, critical thinking, empowerment, innovation, sharing, openness and community resilience are some of the most easily recognizable values (Martelloni et al., 2017).
Individuals with different backgrounds and abilities convene in these spaces for socializing and learning (Dellot, 2015; Moilanen, 2012), in an environment that is open for collaboration and sharing among all participants. Activities like workshops, trainings, collaborative projects and many others are encouraged to facilitate knowledge exchange and promote experimentation with technology on a peer-to-peer (P2P) basis. In addition, all these projects and activities that most of the times are citizen-driven, contribute to tackle different societal issues in their local areas (unemployment, education, urban planning, etc.) and enable these spaces to achieve resilience at community level (Kostakis, Niaros, Dafermos, & Bauwens, 2015).

We can also observe different profiles in Makerspaces and Fab Labs that have different motivations to participate in these collaborative spaces. In OD&M report some kind of personas (Martelloni et al., 2017) have been identified such as i) the agonists (look for plurality in design/making education),

[18] For more information about this initiative check the website http://enablingthefuture.org/
[19] More info at https://fab.city/

ii) the DIYer (passionate about making and crafting), iii) the student maker (engages the makerspace culture to augment traditional curricula) or more traditional roles like entrepreneurs, educators or experts. The kind of profiles that we can find in a makerspace are mainly related to design, digital technologies and digital fabrication tools but all of them share a passion for technology & collaborative work. We may also highlight that individuals don´t engage with makerspaces due to business reasons primarily - they usually already have another jobs or occupations (Dellot, 2015)- but at the same time, several business opportunities can emerge in these spaces as many stakeholders from business, industry and academia are visiting the spaces regularly or are members.

3.4. OPEN DESIGN & OPEN MANUFACTURING

As we have observed previously, the rise of the maker movement has been possible thanks to the popularization of different technologies that have gone into the public domain due to the expiration of a set of patents. The opening and sharing of designs have enabled individuals to access, modify and to rebuild these technologies according to their preferences or needs, creating at the same time alternative paths that have been discarded by main industries. One of them is the rising of Open Design, which has become a quasi-standard for sharing, documenting and disseminating projects. One of the definitions that we can find out of what Open Design actually means is tightly related with the availability of information resources;

> *"Open Design refers broadly to the design, development and distribution of products and systems that are enabled through publicly accessible, shared information resources"* (Green et al., 2017).

This new paradigm of engaging with technological objects suggests alternative models of ownership, production and consumption that promote a more critical attitude towards our relationship with technology. In addition, it has the potential to create new forms of value for makers but also for traditional makers (Green et al., 2017). Nevertheless, new infrastructures are needed for taking care of both parties, given that they hold different interests, motivations and organizational cultures. This is a widely under-explored area of focus and further research is needed to investigate their promising and mutually beneficial interactions (in fact OPENMAKER is one of the first experiences in Europe).

Open Manufacturing can also be interpreted as a new approach to production processes using open source technologies and combining them with sustainability values and social innovation (Hubert, 2010) procedures. Michel Bauwens stresses how Open Manufacturing can be an answer to different challenges that we face regarding sustainability and how physical objects can be produced in an open, collaborative and distributed manner based on open design and open source principles (Michel Bauwens, 2010; Kostakis et al., 2015).

Open Manufacturing combines disruptive and open technologies (such as 3D printers), new values (such as commons-based peer production), new networks (such as Fab Labs or Makerspaces) and open protocols, methods, software and hardware (Dafermos, 2015; Johar, Lipparini, & Addarii, 2015). These new social production (Benkler, 2006) processes are promoted by different grassroots innovation collectives that are characterized by the values of open source communities but instead of producing software, they rather produce physical artefacts through new open technologies that allow fast prototyping. These alternative paths are characterized by the P2P processes (Bauwens,

2005) and the collaborative character of this digital and artisanal production, that can infer new configurations, possibly beneficial for society (Bauwens & Kostakis, 2015). Just to include another views of these ideas, we can also mention The Open Manufacturing Network which claims that *"Open Manufacturing is about bringing free and open source software development methodology and philosophy to the design and construction of the physical world"*[20] while the Institute of the Future talks about *"social manufacturing"* and stresses the socio-economic transformative power of this approach with respect to the way we organize to produce what we need as human societies[21]. Last but not least, the 2015 European Commission policy paper highlights the term "maker manufacturing" and provides a full set of examples of how these initiatives could help revitalizing the European industry (Johar et al., 2015). All definitions share a reference to the maker movement and to open source principles which at the same time are concepts that have been shaped by the hacker ethic (Himanen, 2002) and the DIY spirit (Stangler & Maxwell, 2012).

In the OPENMAKER project we have adopted Open Manufacturing as a leading concept and definition although we are aware the field is still in rapid transformation[22]. In our interpretation, **Open Manufacturing is defined by the application of open source principles to production processes, and is characterized by key concepts such as open data, open software, open hardware, distributed networking, collaboration, sharing and transparency.** The key question is how and to what extent Open Manufacturing can enhance productivity and competitiveness and, at the same time, produce positive social and environmental impact.
Future scenarios are not clear and more research is needed in order to fully understand the new dynamics that are emerging in the platform economy (Kenney & Zysman, 2016) but there is a kind of shared consensus among different agents that Open Manufacturing is not a temporary fashion, as it is been currently embracing by some companies and it will continue to be by others too in the next years. Popular examples like Opendesk, WikiHouse, Fairphone, RepRap, Arduino or Raspberry Pi have shown the way to others and there is a new wave of companies like DFRobot (Silvia Lindtner, Greenspan, & Li, 2015), TokyLabs or OpenROV that are experimenting with open business models and work practices, that allow them to be part of a community that shares knowledge that can be beneficial for both parties, while generating revenue. In this sense we can talk about "P2P entrepreneurship" (Silvia Lindtner et al., 2015) or "P2P innovation" for new forms of collective value generation that are more sustainable, fairer and are not aligned with the exploitation practices that the platform economy (Srnicek, 2017) or the sharing economy (Sundararajan, 2016) are developing under the pervasive upcoming of the digital economy.
The challenges imposed by digitization on current industries will reshape and redefine the entire operational systems as well as their cultural processes. That is why new ways of work and generating value are emerging as digitization. A growing need of autonomy rises due to the introduction of new technologies that demand high skilled profiles but also a more collaborative work that is at the same time a legacy of the Internet Culture and a demand for making a smooth transition to the Fourth Industrial Revolution.

[20] The definition is accessible at http://www.openmanufacturing.net/
[21] For more information see
http://www.iftf.org/fileadmin/user_upload/downloads/researchagendas/social_manufacturing_alt_paths_to_dev_7.19lg.pdf
[22] This was extracted from the OPENMAKER proposal. Number of contract H2020-687941-ICT-10-2015

3.5. CHALLENGES AHEAD

The maker movement has helped to facilitate access for citizens to technology, innovation and R&D processes but it is also facing several challenges for being considered a true, inclusive and democratizing force in society. Some of these challenges are linked to the current ones faced by science, technology and innovation systems at regional, national and international levels and remain unsolved. The techno-optimistic (Sivek, 2011) and techno-solutionism (Morozov, 2014) visions that we can find in the movement are similar to those that we can find in another R & D ecosystems that stresses the role of technology as a cornerstone to overcome societal challenges. In fact, this is clearly related to the stereotypes that are broadly diffused from some successful venture capitalism ecosystems like Silicon Valley being affected by "The Californian Ideology" (Barbrook & Cameron, 1996). A conjunction of values that trace back their roots to the American counterculture of the ´70s and it exhales how society can be changed throughout technology. These ideologies rely on technology for making the world a better place but at the same time can have a lack of social knowledge that is compulsory for addressing complex problems. Their blind confidence in technology is also problematic as technology is not the only solution for societal problems.

The archetype of the maker is something that has been not really well researched so far, but some studies tend to make us think that the same mistakes that linear models have committed might be replicated in these environments (problems in gender inclusivity, lack of social diffusion of knowledge, educational elites, etc.). According to Maker Media, 8 of 10 makers are males, the average age is 44, and related incomes are around 106.000$ and 97% of them have a university degree (80% of them have a master also) (Leonard, 2013). These figures in US are not very different from the ones that can be found in other countries that are also betting high on the maker movement. For instance, the UK and China have also a male predominance with 80% and 77% respectively (Niaros et al., 2017). Despite the need for gathering more representative data about these kind of spaces and collectives, we can infer that the people behind this movement represent an educational elite with motivations that are not met by their current occupations. After all, the main barriers to access this kind of technologies are related to the knowledge base (Morozov, 2014) needed to develop tacit and explicit knowledge (Nonaka & Takeuchi, 1995) necessary for the engagement in these processes.

Moreover, we have to debunk the explosion of creativity that is usually associated with this phenomenon (Kneese, Rosenblat, & Boyd, 2014). Although there is a massive sharing of open designs across different on-line platforms, this does not mean at all that new designs are truly promoted in these networks. In fact, we can say that what is really favored is the replication of a design at worldwide scale. We can also speak more properly of the promotion of a remix model (Perkel, 2006) by these digital ecosystems that are also part of the legacy of the Web 2.0 phenomenon (Tabarés-Gutiérrez, 2015). Moreover, the artisanal component of these creations can be a motive of discussion because their outputs are totally mediated by digital commands that are present in 3D design software, the physical structures that determine the 3D printers, etc.

Last but not least, we would like to draw attention to the emergent startups that are building on the Open Design & Open Manufacturing paradigms, and are facing a lot of common challenges that remain unsolved by the traditional entrepreneurial ecosystem. In this sense, we might expect that

there is still a high “mortality rate” in these incumbent organizations but the truth is that we have no tools to measure yet as they are not present in the “classical channels” for entrepreneurs. In this sense, some reports have highlighted that the future impacts of the maker movement in innovation and entrepreneurship have not been reached yet (Deloitte Center for the Edge & MakerMedia, 2013; Hagel, Brown, & Kulasooriya, 2013).That is why it is so important to acknowledge that there are still several challenges ahead of this emerging phenomenon . **Despite its untapped potential, special resources, skills and approaches will be needed to enable the movement to flourish, but the local grassroots movements might not be in a position to offer that.**

4. OPENMAKER EXPERIENCE

OPENMAKER's main objective is to seed and accelerate the 4th Industrial Revolution – driving the radical distribution, decentralization and mass collaboration between manufacturers and makers. From the beginning, the project has aimed to create a transformative and collaborative ecosystem that fosters collective innovations within the European manufacturing sector and drives it towards more sustainable business models, production processes, products, and governance systems by bringing together manufacturers and makers. In this overall vision, the role of Local Enabling Spaces (LES) has been crucial as it was one of the pillars of the methodology proposed in the project. In this section we explain the approach that has been delivered in the 4 LES and their outcomes.

In fact, OPENMAKER Project can be considered as a programme offering 'space' (local, managed by each LES; and virtual, with the DSP Platform), 'community' (near and far, offered by the LES) and 'content' (ideas pilots, challenges) to people (mainly makers and manufactures, but also with other stakeholder collaboration).

4.1. THE ROLE OF LES

The OPENMAKER project is being offered through 5 hubs (and 5 accelerators in total) distributed across Europe (Italy, Slovakia, Spain and United Kingdom). Each Local Enabling Space (LES) has launched a Pilot Support Scheme (PSS) call that has received 135 applications from all over Europe. Participants presented innovative projects born from strong partnerships between Makers and Manufacturers. Digital manufacturing, 3D printing, waste recycle, AI, Robotics, science-technology, engineering-mathematics (STEM) education - are only few of the fields in which our applicants aim to develop their ideas. Above all, their disruption innovations present great added value in terms of social and environmental sustainability, as well as in terms of social impact.

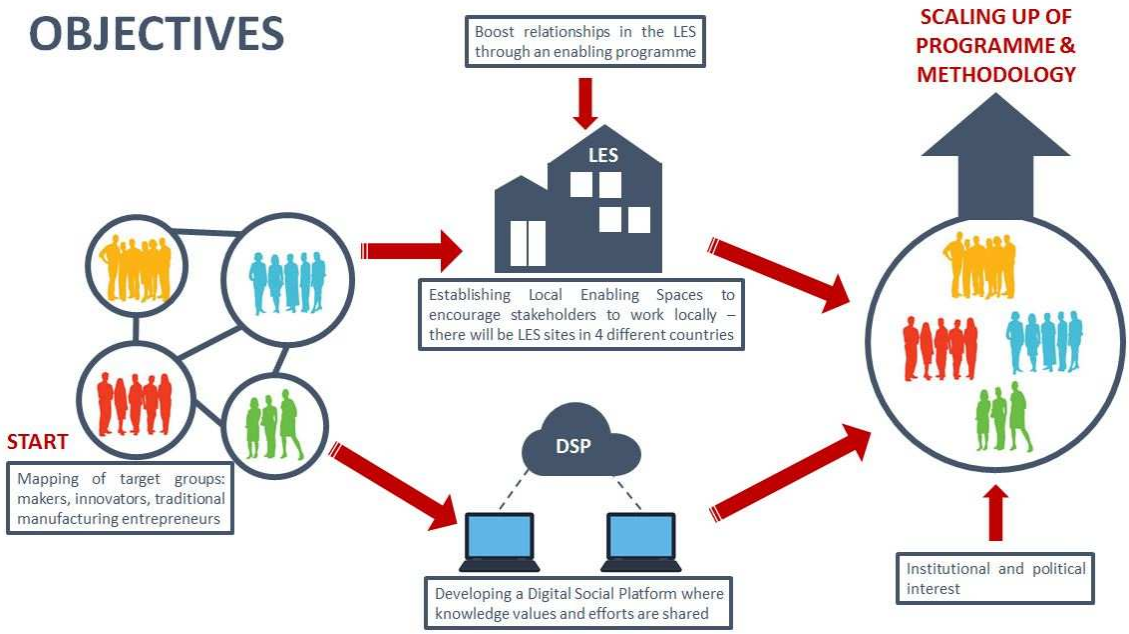

Figure 4. LES approach

Each LES has been built according to the following main steps:

- **Setting up Local Enabling Spaces** (LES), working as activators, connectors and facilitators of meetings and joint initiatives between traditional manufacturing entrepreneurs, makers, citizens and stakeholders; LES also act as hubs of local clusters of "connected LES" in order to seed the scaling-up of the community.
  Related to this task, a series of actions have been carried out:
  - Creation of a database with profiles of the targeted and potential community. To reach the objective is necessary to work in detail the Target Mapping, creating a rich picture of the target community:
    - Traditional manufacturers potentially interested to makers' know-how and skills.
    - Makers. Individual professionals, or SMEs and Micro-enterprises that can be considered as 'Open manufacturing businesses' because of their business model, production process, approach to innovation, adoption of ICTs throughout the overall production process, value chain management.
    - Stakeholders. Organizations and entities of any type that are relevant for our topic, including professional associations, employers and worker's associations, service, software and hardware providers, networking organisations, public institutions, journalists, specialized websites, events and press ('immaterial stakeholders').

  LES must always bear in mind that the community-building process is an iterative process that starts with the mapping and never ends.

  - Training sessions for the teams of Enablers in charge to manage LES.
  - Agreements defining rules and methods for the 4 LES to interact with their respective communities and local stakeholders, with each other and with the connected LES.
  - Supporting tool for the Enablers explaining the model, the activities and the engagement methodologies.
- **Delivering an Enabling Programme within each LES** to encourage meetings and relations between traditional manufacturers and makers leading to the creation of trust and collaborations. The main idea is to create a wide and diverse community and facilitate relationships among its members. Keep in mind that although the work is done in a coordinated manner between the different LES, the realities that we find in each of them are different. There are different social, economic contexts ... and it is necessary to capture those specific needs and adapt the actions to be carried out in each case.
- **Managing a Pilot Supporting Scheme** for enabling the cooperation between traditional manufacturing entrepreneurs and makers into the creation of open manufacturing solutions/technologies.

  An incentive, introduced by each LES, is to complete at least 5 prototyping projects of open manufacturing solutions/technologies, proposed by a partnership including at least one traditional entrepreneur and one maker. Projects will have to clearly proof both their technical feasibility, their market potential, and how their implementation would contribute to solve a social/environmental challenge.

  A panel of experts appointed by each LES award the best 5 ideas/partnerships with 20.000€ each to support the initial phase of pilots as experimental proof of concept (TLR 3) in the next 9 months (max). During the realization phase each LES must organize at least 3 public meetings, with the awarded project collaboration: the first one to present the prototype idea; the second one to present the mid-term state of the art; the last one to present the results.
- **DSP (Digital Social Platform),** a digital environment, in collaboration and in a complementary way with the LES, to stay engaged (online), thereby supporting participants to better develop their social capital and increase their social impact in terms of innovation, knowledge transfer, and business success.
  - Support communication.
  - Enable partnerships between Makers, Manufacturers, researchers and policy makers.
  - Access tailored resources and key community influencers, sourced through algorithms for big data.

All these activities are focused on knowing the business environment / makers / stakeholders, which are around each LES. Being able to be different in each case, considering business realities, innovation, state or regional aid. But all this diversity makes this communication and knowledge sharing between them more interesting and producing.

4.1.1. LESSONS FROM ITALY

The Italian LES is managed by two organizations partnering the OpenMaker project: LAMA Agency and Top-ix, respectively based in Florence and Turin. According to the key model of the Local Enabling Spaces, both organizations leveraged many already existing spaces for co-working and co-creation, makerspaces and innovation labs in the two cities. In turn, other spaces and communities from other cities (specially Milan and Reggio Emilia) were involved as 'satellite' LESs. Indeed, Italy presents a strong manufacturing industry mainly characterized by small and medium sized businesses organized in industrial districts (IDs). Over decades, this typical form of organization of production has allowed to maintain rooms of competitive advantage based on a larger and interconnected mobilization of knowledge and assets. However, increased competition, rising costs, technological progress, higher standards and the global crisis have heavily hit the sector, challenging not only established business models, but also the districts-based system. In this context, there is the yet untapped opportunity to position the maker movement and the network of makerspaces as complementary environments for radical innovation in manufacturing, placing them as 'bridges' and hubs of connection between traditional know-how (particularly in design), and the revolutionary potential brought about by the emerging technologies.

The engagement strategy of the Italian LES has been therefore based on two integrated approaches: on the one hand, it has aimed at getting an in depth understanding of local maker communities, of their ongoing projects and key areas of specialization; on the other hand, it has aimed at better seizing the challenges perceived by local manufacturers for their own competitiveness and sustainability. Stakeholders such as trade unions, universities, public bodies and sectoral associations have been targeted as well.
We have adopted a number of tools such as semi-structured interviews, small workshops and visits to enterprises, transversally combined with inspirational and networking events.

Figure 5. Meeting at Italian LES

Events have been organized not only in Florence, but also in other locations across Tuscany (Siena, Florence, Prato, Lucca) and Emilia Romagna, as well as in Milan, Turin and Rome. While the Industry 4.0 and distributed manufacturing topics have always represented the 'scenario' underpinning such events, the latter have nonetheless dealt with specific topics such as the future of work, new skills and competences, key innovation needs related to products and production processes, democratic and distributed business models, new forms of collaboration and partnerships oriented to disruptive innovation in manufacturing.

Different actors and stakeholders have been therefore targeted, with the overall goal of engaging not only makers and manufacturers, but rather Universities, trade unions, sectoral associations, foundations and investors. The results of the wide geographical scope of the Italian engagement is also shown by the Pilot Supporting Scheme launched by the project: the Italian LES received 30 ideas of prototyping solutions from almost all the country, representing 72 among organizations (70% of them) and individuals (30%). Almost half of the 30 ideas presented at the call for prototypes from the Italian communities were created with collaborations facilitated and stimulated by the Local Enabling Space, both in Florence and in Turin.

Figure 6. Project meeting in Florence

Given that the call was open to all sectors, the Italian LES received ideas from wide variety of sectors, such as Arts and Crafts, Circular Economy, Fashion and Textile, STEM, Health, Accessibility, Furniture, Agriculture, Transport and Mobility, Energy, Design, Building.

After the selection process, five ideas have been selected:

Idea Title	Abstract
COBOPRO – Corrugated Board Prosthesis	The project seeks to create and promote the use of temporary and much cheaper cardboard prostheses at a very low cost and with very good resistance performances, thanks to the network and collaboration of three different partners, with very strong knowhow. This innovative idea, making the cost of the prosthesis very low and its production process very easy, would have a great impact on the market and would facilitate production and delivery of prostheses for hospitals in war zones and emergency areas with poor access to health and medical services.
Digital Crystal Manufacturing (DCM)	The project seeks to digitalize the making of sculpture/crystal artefacts by allowing artisans to reuse molds as well as facilitating the shipping processes of crystal sculptures. Digital crystal manufacturing will leverage on different technologies such as 3D scanning and it will easily allow to copy existing statues “on demand”. Thanks to DCM, once the object/statue becomes a 3D file, it can be sent and managed very easily and without any cost, whereby paving the way to the digital artists of the future.

Tritino	Tritino is a personal, easy-to-use and affordable shredder that allows to recycle plastic waste and transform it with Felfil Evo into brand-new filaments ready to be 3D printed. The partners already sell Felfil Evo, an open source filament Extruder, and have already built up a community around that project.
Circular Wool	This project seeks to find a commercial outlet for the use of rustic Tuscan wool on a semi-industrial scale. This type of wool is taken from sheep from the meat industry that is typically too coarse to be considered of interest in the textile industry and hence it is treated as toxic waste in the best-case scenario. This would enable the economic recovery of small wool producers and the avoidance of land and air pollution from inappropriate disposal methods.
H.B.R.T – how to be a Robot Trainer	In the forthcoming years, artificial intelligence will become increasingly important in the school sector and in the educational toys market. in anticipation of this trend, the project proposes to design a small cheap robot, using Arduino board to introduce A.I. in schools, in the educational robotics sector and more generally in the STEM toys market. H.B.R.T. is planning to create a robot that, through interaction with the environment and a child as a trainer by using "machine learning" algorithms, "learns" from the beginning the best strategy to get out of a labyrinth that is always different and gradually more complex.

The community of OM in Italy is composed of around 300 people: 60% of them are makers and digital/technical experts, 25% are manufacturing companies, almost entirely SMEs, and 15% are other stakeholders (trade unions, universities, public bodies and sectoral associations, innovation brokers, angel investors).

4.1.2. LESSONS FROM SLOVAKIA

The Slovak accelerator has been managed by Centire – a consultancy company based in Bratislava. During its years of operation, Centire has developed a large network of contacts and cooperation with small and medium enterprises across Slovakia. Moreover, Centire has also closely cooperated with different stakeholders such as chambers of commerce, professional association or universities. These partners have been crucial for addressing the project target groups. Slovakia belongs among the most industrialized countries of the European Union. Small and medium-sized enterprises in Slovakia account for 99.9% of the total number of business entities, providing employment in the business economy with almost three quarters (74.1%) of active labour force and accounting for more than half (52.7%) in creating added value. 97% of small and medium-sized enterprises employ less than 10 employees. More than three quarters of small and medium-sized enterprises are active

in sectors such as business services, trade, construction and industry.[23] Lately, the topic of the 4.0 Industry has been promoted intensively in Slovak business sectors, driven mostly by the chambers and associations.

On the other hand, the maker movement concept is relatively new to Slovakia. There are many "islands" of maker communities across Slovakia, but the term "maker" has been used rather rarely. Most of the makers belong to the creative sector, completed with makers concentrated in innovative companies or universities. Additionally, the concept of open innovation has not been significantly disseminated across Slovakia either. Elements of the open innovation concept have been detected in the manufacturing sector across Slovakia, but emerging more autonomously and spontaneously rather than a part of the concept introduction.

The first months of the project implementation in Slovakia were used to analyse the eco-system and interactions of the main target groups (makers and manufacturers). Semi-structured interviews helped to (1) explore the needs of the target groups; (2) recognize the influencers and (3) identify other potentially interested makers and manufacturers. Significant activity consisted of identifying the key players – institutions - "knots"- of trust and recognition provided by the target groups. These key institutions turned out to be crucial elements for addressing and involving the project target groups. The main key intermediaries comprised chambers of commerce, professional associations and universities.

Centire launched its own registration system for those interested in project activities prior to the platform launch. To date, 25 makers, 28 manufacturers and 4 representatives of other subjects have been registered. The OpenMaker contact database has been constantly updated with contacts of the participants attending the events. Currently, the contact database includes more than 700 contacts used for events organizing and newsletter distribution.

The events have been the key activities for stimulating networking and cooperation between manufacturers and makers. The Slovak accelerator has hosted three different types of events (1) presentations; (2) thematic workshops and (3) matchmaking workshops. The project presentations introduced the project and its benefits and were used mainly for promoting the piloting supporting scheme. The thematic workshop topics were selected regarding needs and preferences of the target groups. Their preferences were continuously collected via questionnaire distributed at the events or online.

[23] http://www.sbagency.sk/sites/default/files/image/msp_v_cislach_v_roku_2016_final_v_20_10_2017_002.pdf

Figure 7. Meeting at Slovakian LES

The aim of the matchmaking workshops was to present cooperation opportunities provided by makers or manufacturers. Altogether, five matchmaking workshops were organized resulting in new partnerships even participating in the Pilot Support Scheme. Besides Bratislava, the Slovak accelerator has organized events in Trencin, Zilina, Banska Bystrica, Zvolen and Presov – covering the majority of Slovakia. Moreover, one presentation was conducted even in Brno, in the Czech Republic.
Besides events, makers and manufacturers named the Pilot Support Scheme as the most attractive activity within the OpenMaker project. The Pilot Support Scheme allowed testing or implementation of the joint innovation projects of maker(s) and manufacturer(s). Altogether, the Slovak accelerator received 51 project applications, from most of the whole project consortium. The Pilot Support Scheme attracted project consortia from all Slovakia. The submitted projects were dominated by STEM, followed by circular economy, design and arts & crafts.

After the selection process, five ideas have been selected:

Idea Title	**Abstract**
Eco-social Innovation	The project aims to close the loop in the textile industry by turning unwanted clothing and textile waste, which often end up in landfills, into a resource. By partnering with charity warehouses, NGOs and retailers, Sobi aims to help them reintroduce old clothing as new-brand products made of recycled non-woven fabric, while employing people at social workshops. They are able to process all the textile waste, even destroyed clothing and blended fibers textiles, which are the most challenging for the circular economy. Their recycled products will be made available to individuals and to companies as personalized branded gifts to key customers, employees

	and other relevant stakeholders. Through such products, they want to raise awareness about new eco-social possibilities, responsible consumption and production.
BIOplastic Material development for intermediate and final products	BIOM is a pilot project aiming to develop a renewable, biodegradable material that can replace oil-based plastic. Previous prototypes lacked logistical infrastructure at the collection stage and the material was only biodegradable in industrial compost. The novelty of 2nd generation material is its revolutionary ability to be home-composted. The ground-laying activity includes the development of a granulate from new material mixture with the required stability and temperature resistance. An automated production process (pressing, injection molding) is established to produce intermediate sheets needed for the design objectives and material datasheets. Two other main activities are based on designing final products: glasses and cups.
CLAY NEXT - 21st century ceramics	The goal of the project is to launch new brand of 3D printed, on demand homeware titled “CLAY NEXT” to connect consumer electronics, digital fabrication tools and local craft production. Thanks to practical product design and fulfilment of market needs CLAY NEXT allows to link the traditional ceramics production to contemporary lifestyles and attractive forms. It aims to disrupt the image of traditional ceramic-making and to bring back local crafts products “Made in Slovakia”. Low volume 3D printing production allows not only mass customization of products, it also allows for freedom of shape, high resolution details and, most importantly, the effective use of material.
Light in the Dark	TuLiMark aims to keep tourists safe on marked, hiking trails. The project is based on a technical solution that uses the latest knowledge in passive navigation to develop a light travel brand equipped with its own electronics. In case of reduced visibility or poor weather conditions, this technology illuminates the path to follow for the time required to reach the target, while not causing interference to the surrounding nature. The length and the intensity of the light will be programmed separately for each hiking trail. The energy for the lights will be delivered thanks to an integrated, rechargeable battery pack that comes from renewable sources.
Extreme Motors	The solar energy prices have significantly dropped to 0,0167 Euro/kWh, while the prices of energy from the grid is around 0,21 Euro/kWh. Such prices simply represent a disrupting process: a complete reorientation of the energy sector and the price of solar energy will drop even lower. To take advantage of this opportunity window, XtMOS aims to develop integrated motors for solar transport with high efficiency, personal solar transport drones, and small power biomass power plants with wide velocity and power range.

The success of the Pilot Support Scheme may be credited to the intensive online and offline campaign. The interest in the Pilot Support Scheme also provided a high registration rate of Slovak users on the platform. At this time, 118 users from Slovakia are registered on the platform. To keep the momentum and interest of the target groups, Centire will launch an innovation competition in the upcoming months. Manufacturing companies will release their innovation briefings – problems to be solved or opportunities for innovation implementation. Makers will develop their innovative solutions and subsequently present it to the involved manufacturing companies. This way, manufacturing companies will gain a spectrum of innovative solutions. Makers will gain the opportunity to promote their innovative ideas and, potentially, establish a long-term cooperation with manufacturing companies.

The main lessons learnt include: (1) to test and adjust the wording and promotion channels according to the target groups; (2) to involve the key partners – universities and umbrella organizations such as chambers of commerce and professional associations (especially in promoting new concepts - such as open innovation) and (3) to continuously maintain the interest of involved target groups representatives with different project activities.

4.1.3. LESSONS FROM SPAIN

The main objective of the Spanish Accelerator is to enable and support the collaboration between the local manufacturing industry and the maker's communities to create cross-boundary partnerships, build a joint community for knowledge sharing and ultimately contribute to the creation of the ecosystem needed to shape the "Basque Industry 4.0" path. During the lifespan of the project, it offers a structured program of events and capacity-building for manufacturers, makers and stakeholders, while allowing the experimentation of new products and production processes, as well as the co-design of innovation strategies.

This Accelerator is managed by Fundación TECNALIA Research & Innovation and is located in Bilbao. In this accelerator several activities have been held in different locations and facilities around the Basque Country and in other regions to maximize the impact of the activities. The aim of the accelerator program is to engage maker communities, to identify local needs of traditional manufacturers and to promote a shared vision of the different agents that take part in this ecosystem of open manufacturing.
Different showcase events, trainings, thematic workshops and contests have been supported for developing the 5 open manufacturing prototypes that tackle real problems of traditional manufacturers.

Figure 8. Kick Off event of Spanish LES

At the time that this report is written there are 63 makers, 28 manufacturers and 29 stakeholders that are lively participating in different events, channels and activities. The informal network is much bigger as we can count up to 181 people that are regularly updated about the project by e-mail or other media. More communication activities are held through social media and websites.
The profile of the manufacturing companies that participate in the project are SMEs and most of them are in the industrial design sector. This has been the most notable difficulty of the project so far, because it has been really challenging to attract the heavy industry and engage them with the community of innovators. Differences between innovation cultures and traditional business models are barriers that make difficult to attract other companies that are immersed in their routines and have no time to participate in this community. This will be considered for the next phase of the project where different measures to involve more traditional companies will be taken.

On the other hand, makers and stakeholders have been really active and have embraced quite easily the narrative of the project. They have been picking up the language from the very beginning and they have been a transformative force for inviting other participants or contributing to the community with their work.
In this accelerator several activities have been held in different locations (Bilbao, Zamudio, Miñano, Miramon) and facilities around the Basque Country and in other regions to maximize the impact of the activities. Below, some of the most representative activities carried out:

- Matchmaking and MiniFaire event in Yimby (http://www.yimbybilbao.com/) with the support of the Basque Government and more than 70 participants. More than 30 Face to Face meetings with manufacturers and to help them identify possible project ideas.
- Semi-structured interviews mainly with makers and other relevant actors of the Open Manufacturing movement.
- According to the feedback gathered in these and other actions, we have been able to know that one of the issues that most mattered to our community was the different forms of collaboration. For this reason, a specific workshop on “Open Licenses and

Collaborative Contracts with the Collaborative Law Association of the Basque Country and Expert Lawyers on Open Licenses" was held on this topic, as requested by the LES community.

Regarding participation in the PSS, a set of 30 proposals have been presented, from many different areas: 3D printing, clay, underwater robot inspection, kitchen robot open hardware, STEAM prototyping, health, mobility, PET recycled, circular economy, pollution, GNSS, acoustics, mechatronics, etc.

Between all of them, ideas selected are:

Idea Title	Abstract
Fall Early Notice and Position System (FENPS)	FENPS is a joint project that allows early warning for disorientation or fall of elders and dependents in general. Warning in any of its devices will be sent to relatives, institutions or associations concerned about their well-being. Devices will be developed to detect problems and report the incident through a wireless network specifically designed for the Internet of Things (IoT) due to its ease of installation, coverage area and price. The platform will have vertical and horizontal growth capacity: vertical since it allows to incorporate devices that measure new parameters easily, and horizontal because it is very easy to increase the coverage area of the solution, as well as its replication in other cities.
3D SLM Printer	The project aims to design, manufacture and commercialize high quality 3D metal printers using SLM (Selective Laser Melting) technology for the industrial, aeronautical, dental, prosthetic and prototyping sectors. This printing technology unlike the popular FDM 3D printers obtains end pieces with metallic materials and excellent mechanical qualities. In many cases, the pieces obtained by this technology are impossible to manufacture by other means.
JETCLAY	JetClay seeks to develop a dry clay extruder for ceramics and 3D printing. This could accelerate innovation at the crossroads between digital fabrication and the ceramics sector, which accounts for EUR 27.8 billion in production value. Ceramics is a natural material, completely recyclable and with relevant material properties in relation to thermal insulation, resistance to chemical attack, low conductivity and resistance to high temperatures, to name just a few. The team behind the project includes engineers, ceramic material experts, designers and tool machining specialists, offering a unique perspective and allowing to accumulate a strong knowledge base.
Green Divisor 3D Clay Wall	Thanks to 3D additive printer technique, the project promotes a modular system of 'flower beds' made of baked clay, which allow to efficiently create green domestic or urban spaces. The system allows to build green divisions and spaces, by heaping up several units with the same shape and with the

	help of some special units to finish or bend the wall. 3S technology allows to create empty spaces inside the flower beds, where the water can be stored and flow from one to another, avoiding watering to the maximum. The flexibility of the system allows to adapt the system to different configurations as well as different aesthetic preferences.
Aquapioneers	The project aims to promote sustainable urban farming in households, offices and schools with a process called Aquaponics, an ancient cultivation technique that allows to cultivate on water without soil, making use of the fish excrements as fertilizer. It is 100% organic, twice as fast as traditional agriculture and saves 90% of water compared to traditional agriculture. Aquaponics is ideal for growing food all year round and vertical farming, a great match for the lack of space in cities. The first invention of the team is called "Aquapioneers Ecosystem" and combines an aquarium and a garden in a compact wooden design and it is the first open source Aquaponics Kit designed for urban farming.

LES community is being continuously updated about the needs of their members, their features and what are the main interests for being part of this. This knowledge will be greatly increased with the follow-up, very closely, of the development of the projects, financed by the PSS initiative and will produce valuable insights to produce methodologies of accompaniment that can benefit future projects that will bridge manufacturers and makers.

4.1.4. LESSONS FROM UK

The UK program is being run by The Beautiful Ideas Co. (BICo), established in July 2014 by a collective of local entrepreneurs and leaders in North Liverpool. It is currently chaired by Assistant Mayor Councillor Nick Small on behalf of Liverpool City Council alongside representatives drawn from the local private and social sectors and from Liverpool John Moores University. BICo has established a sustainable social investment fund which is derived from match day parking provided on changing plots of unused land near two of the UK's professional Football Clubs.
Since its creation, BICo has been contracted to deliver programmes in Birmingham, Salford Greater Manchester, The Wirral and Wales with any contract profits returned to North Liverpool.
By December 2017 BICo had invested £484,300 of its own resources resulting from match day car parking in a footballing district, levering £656,000 of other social investment, into 48 ventures, employing 50 people full time and 80 people part time plus contracted and seasonal staff. Additionally, circa 60,000 square feet has been brought back into use so far with further space likely to be realised in 2018.

The Beautiful Ideas Co had invited proposals from across the economic spectrum and yet found that over 60% of ventures were led by creative, digital and sharing economy entrepreneurs. The Beautiful Ideas Co and OPENMAKER program is led by Erika Rushton (female)- a creative economist with 30 years' experience of area based and creative regeneration and enterprise support. She is currently chair of Baltic Creative where over 100,000 square feet of unused warehouses have become the second fastest growing creative & tech district outside London supporting 1,500 new creative and digital jobs. She was also chair of Granby Four Streets Community Land Trust where 200 homes, some empty for over 30 years, were brought back into use as a result of creative and entrepreneurial interventions. Granby 4 Streets worked with Assemble – an artists and architects collective – and won the UK's most prestigious arts award – The Turner Prize.

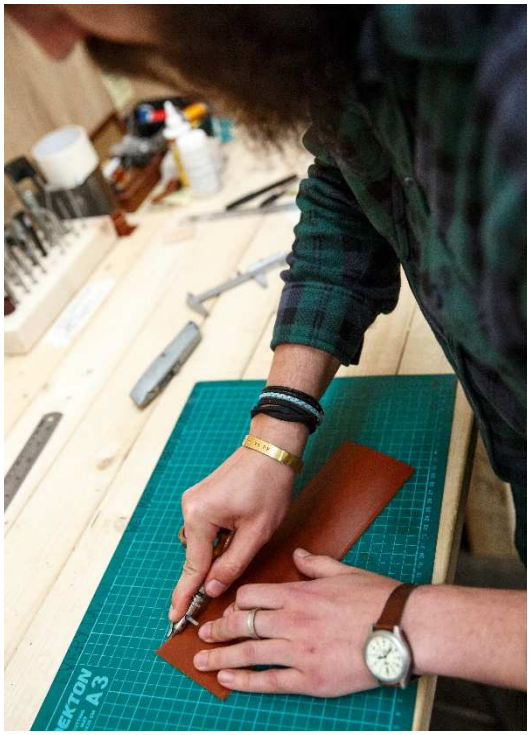

Figure 9. Participant of LES UK

OPENMAKER benefits from and is embedded within this growing creative, digital and maker DIY economy that is emerging in the UK's North West. It builds on activities, and contributes to Maker Communities that are growing in Liverpool where over 1,500 people are now active and Great Manchester where around 150 people are active. Applications were generated through a series of seminars and workshops run in conjunction with Baltic Creative, Sensor City, Liverpool Fab Lab, Maker Liverpool maker space, and Islington Mill Arts Club with support from the LCR 4.0 programme being run by the Local Enterprise Partnership and 2 Universities.

Our learning to date: Interest in and applications to OPENMAKER reflected the traditional industries in the region from both makers and manufacturers. The program appealed to small and medium manufacturers who are less well served by existing support such as LCR 4.0. It was evident at an early stage in the paving events that 70% of women were attracted to the programme's marketing but this was not reflected in applications. Action was taken to support applications from Women resulting in 50/50 submission applications from men and women. After local selection by gender balanced panel women made up 60% of the 10 projects shortlisted. However, the international jury, made up predominantly of men, selected all 4 projects led by men and one if the women led projects.

Figure 10. Workshop held at LES UK

The selection also appeared to favour traditionally male interests/sectors over traditionally female interests/sectors. Local research is now being taken to understand how this can inform future programs and selection panels. Initial consultation with winning projects suggest they key issues they are seeking support on include legal, trademarks, intellectual property and partnering; showcasing support; access to appropriate manufacturers necessary to their supply chains; a community of support/network; the support to turn ideas into mvp's; marketing and communications assistance; and access to investment for the prototypes being developed at the end of the program.

The winning projects were:

Idea Title	Abstract
Liverpool Aqua Farm	Liverpool Aqua Farm is a maker-manufacturer collaboration to deliver a modular, off-grid, aquaculture pilot to produce local food in urban settings, using disused spaces. The test bed will be at Clarence Graving Dock in North Liverpool. It will produce fresh fish, seaweed and shellfish, addressing the challenges of scale-up for commercial operation of existing off-grid services and of modularity for flexible scalability, to allow replication in any location. Future phases envisage the aquafarm as the start of an SME cluster and visitor destination promoting food innovation and sustainability.
FUEd by Farm Urban	FUEd by Farm Urban will create a first version of FUEd: a powerful, responsive and integrated educational tool designed to keep a pace with Industry 4.0. An integrated digital platform enables high school students to explore real-world problems through up-to-date technologies. Far Urban's approach places curiosity and self-directed problem-solving at the heart of

	learning, allowing students to participate in collaborative research and citizen science experiments based around Industry 4.0 technology, equipping them with the skills they need in the new world of work.
Aqua Running – Wearable Sensor	Aqua Running – Wearable Sensor Technology - have developed a unique bodysuit which allows anyone of any age, ability or disability to exercise comfortably in deep water with no impact on bones, joints and muscles. The Aqua Running X6 suit is a buoyancy suit with 19 strategically placed buoyancy pads, which keep a person's head above water and activates core muscles to help correct running and jogging position in the water. This allows the wearer to exercise safely with no risk of injury very early in recovery from surgery, illness or injury, in turn reducing recovery and rehabilitation time significantly. It is also an excellent aid for those learning how to swim and for professional sportsmen and women. The next stage of development is to integrate sensors into the suit, a new technology that retrieve physiological data of the patient's recovery and monitor exercises. The suit is already being trailed at Real Madrid.
Microhome	Microhome is an affordable live & workspace which will be fitted out in a unique range of custom design prototypes. Microhome responds to the crisis in the UK where homelessness has doubled in 4 years and creative producers, essential to sustainable urban economies, are being forced out. Microhome is delivered to site fully assembled and is 'plugged in' to services on temporary, permanent, small, and infill sites. It can be used on sites too small for commercial value, difficult locations and assets awaiting long term value or site assembly. It has a unit cost of £25-35,000 allowing for rents of £40 to £100 per week. Microhome will be built & tested with a live residential community and exhibited at the National Housing Federation showcase on land donated by Salford Council for 5 years.
JANE	JANE aims to get companies to work together in new ways, realising existing assets in new distribution channels. The proposal is to 1. Create professional quality, self-contained 3D scanners (Objocopiers) that are as easy to use 2. Verify the scanner design by collaborating directly with five pairs of creative and manufacturing businesses in the Merseyside region 3. Use the results of these collaborations to refine two more Objocopiers.

5. FUTURE DIRECTIONS FOR POLICY MAKING

The spirit of this document is how to support collaboration between manufacturers and makers for promoting an open innovation ecosystem that can help to meet the gaps that the digitization of industry can create in Europe and promoting at the same time a democratization of manufacturing. At this point of the project it is still ambitious to declare what are the main recommendations for policy-makers as we have still ten months remaining to understand what are the specific needs of the two target groups (makers and manufacturers) and the barriers that impede them to work together properly. The funded pilots will start in March 2018 and we have still more pending interviews with manufacturers, makers and stakeholders to complete the 240 that were planned at the beginning of the project.

However, we would like to provide in this first version a glimpse of what are our first insights about these two communities and how can be empowered, to promote a common understanding of each other and to enable collaborations between them for creating powerful synergies. OPENMAKER hosted on the 18th of October a meeting with several policy-makers in the European Parliament for celebrating the launching of The European Maker Week 2018[24]. The objective of the event was to create awareness about the potentialities of the maker movement and learning from personal experiences of entrepreneurs already engaged on it. During the meeting, Pavel Telicka, Vice President of the European Parliament recognized the importance of bridging these two collectivities for helping them in their initiatives; *''Makers and entrepreneurs need the support of policy makers, and institutions need to provide the ideal conditions for makers. It is crucial to bridge the gap between the two, simply to make makers more aware of different tools such as the EFSI that can provide them with the resources to develop their projects'.*

In this event some recommendations for the European Institutions were delivered to the attendees to solicit feedback for them. These were the following;

- **To support makers in connecting with manufacturers, artists, researchers and policymakers** through the establishment of a network that could not only increase awareness about the movement but also facilitate connections and "dispense opportunities" through networking events, online platforms, workshops, discussion for a and workspaces. The network would gather existing local hubs and build on existing connections, whilst being open to new ones. The network would also include private investors and connect stakeholders globally.
- **To make EU funding more accessible for makers and manufacturers** both at EU and national level by simplifying the EU Financial Regulation for grants and tender, public procurement rules and terms of reference for existing programmes (i.e. SMEs instrument), especially for those innovations with a strong social impact. Not only smaller and more flexible grants are needed for the prototyping phase but there is also a need to develop an "orientation tool" to help them finding their way through all the EU funding possibilities.
- **To initiate dedicated initiatives for makers** - not simply mention the movement in policy proposals– aiming to encourage the development of new ideas and equally supporting those that have already developed a prototype and need start the commercialization phase.

[24] More information of the event at http://openmaker.eu/2017/10/15/penmaker-to-officialy-launch-the-european-maker-week/

- **Encourage creativity and entrepreneurship for young people**, through formal and informal education, including dedicated programmes for rough neighbourhoods or targeting vulnerable groups

In the next version of the document and after completing our ethnography research, supporting our PSS winners and understanding in a deeper way makers and manufacturers, we will provide a full set of recommendations that can help to policy-makers for establishing measures oriented to those collectivities for creating fruitful collaborations that can result in meaningful partnerships and technological socially-oriented innovations in the transition to the Industry 4.0 paradigm.

At this point we would like also to provide room for a policy consultation that can ask to manufacturers and makers as well as other kinds of stakeholders that are enticed by open manufacturing paradigm different kind of stakeholders on how we can promote this cooperation after the project and creating sustainable synergies that can last and be embraced by other actors. We would like to hear thoughts and opinions from different players to create an improved revised version of this document and helping policy-makers in their actions. During our next stage we will try to provide detailed answers to questions that we have started to answer in this document such as: **How we can foster synergies between these two collectivities? What infrastructures are needed to establish permanent partnerships? What are the right incentives for promoting collaboration between them?**

6. BIBLIOGRAPHY

Anderson, C. (2012). *Makers: the new industrial revolution*. Random House.

Atkinson, P. (2006). Do It Yourself: Democracy and Design. *Journal of Design History*, *19*(1), 1–10. https://doi.org/10.1093/jdh/epk001

Barbrook, R., & Cameron, A. (1996). The Californian ideology. *Science as Culture*, *6*(1), 44–72. https://doi.org/10.1080/09505439609526455

Bauwens, M. (2005). The political economy of peer production. *CTheory*. Retrieved from http://www.informatik.uni-leipzig.de/~graebe/Texte/Bauwens-06.pdf

Bauwens, M. (2010). The Emergence of Open Design and Open Manufacturing. Retrieved April 5, 2017, from http://www.we-magazine.net/we-volume-02/the-emergence-of-open-design-and-open-manufacturing/#.WOSgTWclHIU

Bauwens, M., & Kostakis, V. (2015). Towards a new reconfiguration among the state, civil society and the market. *The Journal of Peer Production*, (7). https://doi.org/10.1017/CBO9781107415324.004

Benkler, Y. (2006). *The Wealth of Networks: How Social Production Transforms Markets and Freedom*. New Haven and London: Yale University Press.

Brynjolfsson, E., & McAfee, A. (2014). *The Second Machine Age*. New York: Norton & Company.

Dafermos, G. (2015). Transforming the productive base of the economy through the open design commons and distributed manufacturing. *The Journal of Peer Production*, (7). Retrieved from http://peerproduction.net/issues/issue-7-policies-for-the-commons/peer-reviewed-papers/distributed-manufacturing/

Davies, R. (2015). *Industry 4.0 Digitalisation for productivity and growth*.

Dellot, B. (2015). *Ours to Master: How makerspaces can help us master technology for a more human end*. London.

Deloitte Center for the Edge & MakerMedia. (2013). *Impact of the maker movement*. *Maker Impact Summit Dec. 2013*. Retrieved from http://makermedia.com/wp-content/uploads/2014/10/impact-of-the-maker-movement.pdf

DiMaggio, P., & Hargittai, E. (2001). From the “Digital Divide” to “Digital Inequality”: Studying Internet use as Penetration Increases, *15*, 1–23. https://doi.org/10.1002/bem.20484

Dougherty, D. (2012). The Maker Movement. *Innovations: Technology, Governance, Globalization*, *7*(3), 11–14. https://doi.org/10.1162/INOV_a_00135

EU Skills Panorama. (2014). *Advanced manufacturing Analytical Highlight*. https://doi.org/10.1007/BF01176301

European Commission. (2013). *Factories of the Future - Multi-Annual Roadmap for the contractual PPP under Horizon 2020*. Brussels.

European Commission. (2017). *Investing in a smart, innovative and sustainable Industry. A renewed EU Industrial Policy Strategy*. Brussels.

Farrell, J., & Klemperer, P. (2007). Coordination and lock-in: Competition with switching costs and network effects. *Handbook of Industrial Organization*, *3*, 1967–2072.

Ferger, A., Lau, W., Ross, P., Zhao, W., Sayama, H., & Rasmussen, S. (2013). Impact of Personal Fabrication Technology on Social Structure and Wealth Distribution: An Agent-Based Simulation Study. *Advances in Artificial Life, ECAL 2013*, 521–522. https://doi.org/10.7551/978-0-262-31709-2-ch075

Gareis, K., Hüsing, T., Birov, S., Bludova, I., Schulz, C., & Korte, W. (2014). *E-skills for jobs in Europe: Measuring progress and moving ahead.*

Gershenfeld, N. (2005). *Fab: The coming revolution on your desktop - From personal computers to personal fabrication*. New York: Basic Books.

Green, D. P., Bjorn, P., Reiter, A., Fuchsberger, V., Kirk, D., Taylor, N., … Lindtner, S. (2017). Open Design at the Intersection of Making and Manufacturing. In *Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems - CHI EA ’17* (pp. 542–549). Denver. https://doi.org/10.1145/3027063.3027087

Hagel, J., Brown, J. S., & Kulasooriya, D. (2013). *A movement in the making*.

Haring, K. (2008). *Ham Radio´s Technical Culture*. Cambridge, Mass: The MIT Press.

Himanen, P. (2002). *La ética del hacker y el espíritu de la era de la información*. Barcelona: Destino.

Hubert, A. (2010). *Empowering people, driving change: Social innovation in the European Union*. *Bureau of European Policy Advisors (BEPA)*.

IEC. (2015). *Factory of the Future*. Switzerland. https://doi.org/Strategie

Johar, I., Lipparini, F., & Addarii, F. (2015). *Making Good our Future - Exploring the New boundaries of Open & Social Innovation in Manufacturing*. Retrieved from https://webgate.ec.europa.eu/socialinnovationeurope/sites/default/files/sites/default/files/SIE - Making Good our Future - May 2015.pdf

Kenney, M., & Zysman, J. (2016). The Rise of the Platform Economy. *Issues in Science and Technology*, *32*(3), 61.

Klemperer, P. (2006). Network Effects and Switching Costs: Two Short Essays for the New Palgrave. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.907502

Kneese, T., Rosenblat, A., & Boyd, D. (2014). *Technologically Mediated Artisanal Production*. *Future of Work*. New York. Retrieved from http://www.datasociety.net/pubs/fow/ArtisanalProduction.pdf

Kostakis, V., Niaros, V., Dafermos, G., & Bauwens, M. (2015). Design global, manufacture local: Exploring the contours of an emerging productive model. *Futures*, *73*, 126–135. https://doi.org/10.1016/j.futures.2015.09.001

Kostakis, V., & Papachristou, M. (2014). Commons-based peer production and digital fabrication: The case of a RepRap-based, Lego-built 3D printing-milling machine. *Telematics and Informatics*, *31*(3), 434–443. https://doi.org/10.1016/j.tele.2013.09.006

Kuznetsov, S., & Paulos, E. (2010). Rise of the Expert Amateur : DIY Projects , Communities , and Cultures. In *Proceedings of the 6th Nordic Conference on Human-Computer Interaction: Extending Boundaries* (pp. 295–304). ACM.

Leonard, A. (2013). The Maker economy can't fix everything. Retrieved June 22, 2017, from http://www.salon.com/2013/07/26/the_maker_economy_cant_fix_everything/

Levy, S. (2010). *Hackers: Heroes of the Computer Revolution*. *O'Reilly*. New York: Dell Publishing. https://doi.org/10.1016/0267-3649(86)90036-1

Lindtner, S. (2014). Hackerspaces and the Internet of Things in China: How makers are reinventing industrial production, innovation, and the self. *China Information*, *28*, 145–167. https://doi.org/10.1177/0920203X14529881

Lindtner, S. (2015). Hacking with Chinese Characteristics: The Promises of the Maker Movement against China's Manufacturing Culture. *Science, Technology & Human Values*, *40*(5), 1–26. https://doi.org/10.1177/0162243915590861

Lindtner, S., Bardzell, S., & Bardzell, J. (2016). Reconstituting the Utopian Vision of Making. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems - CHI '16* (pp. 1390–1402). San Jose. https://doi.org/10.1145/2858036.2858506

Lindtner, S., Greenspan, A., & Li, D. (2015). Designed in Shenzhen: Shanzhai Manufacturing and Maker Entrepreneurs. In *Aarhus Series on Human Centered Computing* (Vol. 1, p. 12). Aarhus: ACM. https://doi.org/10.7146/aahcc.v1i1.21265

Lindtner, S., & Li, D. (2012). Created in China: The Makings of China's Hackerspace Community. *Interactions*, *19*, 18–22. https://doi.org/10.1145/2377783.2377789

Lipson, H., & Kurman, M. (2010). *Factory @ Home : The Emerging Economy of Personal Fabrication*.

Locoro, A., Cabitza, F., & Mari, L. (2017). IS MAKING THE NEW KNOWING ? TANGIBLE AND INTANGIBLE KNOWLEDGE ARTIFACTS IN DIDIY. In *Proceedings of the 25th European Conference on Information Systems (ECIS)* (Vol. 2017). Guimaraes: AIS Electronic Library (AISeL).

Lundvall, B.-A. (1992). *National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning*. London: Pinter Publ.

Martelloni, L., Lobascio, A., Como, E., Giorgi, D., Lotti, G., Fiesoli, I., … Tabarés-Gutiérrez, R. (2017). *Universities , Enterprises and Maker Communities in Open Design & Manufacturing across Europe : An exploratory study*. Retrieved from http://odmplatform.eu/wp-content/uploads/2017/05/D3.1-ODM-Research-Report-Integral.pdf

Moilanen, J. (2012). Emerging hackerspaces - Peer-production generation. *IFIP Advances in Information and Communication Technology*, *378 AICT*, 94–111. https://doi.org/10.1007/978-

3-642-33442-9_7

Morozov, E. (2014). Making It. Retrieved April 12, 2016, from http://www.newyorker.com/magazine/2014/01/13/making-it-2

Mota, C. (2011). The Rise of Personal Fabrication. In *Proceedings of the 8th ACM conference on Creativity and cognition* (pp. 279–288). ACM.

Niaros, V., Kostakis, V., & Drechsler, W. (2017). Making (in) the Smart City: The Emergence of Makerspaces. *Telematics and Informatics*. https://doi.org/10.1016/j.tele.2017.05.004

Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company: How Japanese companies create the dynamics of innovation*. New York: Oxford University Press.

Pazin, Ž. (2017). Factories 4.0: The Future of European Manufacturing. Retrieved November 29, 2017, from https://ec.europa.eu/digital-single-market/en/blog/factories-40-future-european-manufacturing

Perkel, D. (2006). Copy and paste literacy? Literacy practices in the production of a MySpace profile. *Xxxix. Informal Learning and Digital Media: Constructions, Contexts, Consequences*. Retrieved from http://people.ischool.berkeley.edu/~dperkel/writing/perkel_copypasteliteracyDRAFT_August2007.pdf

Rheingold, H. (1996). *La comunidad virtual: una sociedad sin fronteras*. GEDISA.

Rheingold, H. (2007). *Smart mobs: The next social revolution*. Basic Books.

Russell, A. L. (2014). *Open standards and the digital age. History, ideology and networks.* New York: Cambridge University Press.

Scholz, T. (2012). *Digital labor: The internet as playground and factory*. New York: Routledge.

Schwab, K. (2016). The Fourth Industrial Revolution: what it means and how to respond. Retrieved February 22, 2017, from https://www.weforum.org/agenda/2016/01/the-fourth-industrial-revolution-what-it-means-and-how-to-respond/

Sivek, S. C. (2011). “We Need a Showing of All Hands”: Technological Utopianism in MAKE Magazine. *Journal of Communication Inquiry*, *35*, 187–209.

https://doi.org/10.1177/0196859911410317

Smith, A. (2017). *Social Innovation , Democracy and Makerspaces* (SPRU Working Paper Series (SWPS), 2017-10 No. 1–18). https://doi.org/10.13140/RG.2.2.30640.35843

Smith, A., Hielscher, S., Dickel, S., Söderberg, J., & Oost, E. van. (2013). *Grassroots digital fabrication and makerspaces: reconfiguring, relocating and recalibrating innovation?* (SPRU-Science and Technology Policy Research No. 2013–02). Retrieved from http://www.researchgate.net/publication/258835556_Grassroots_Digital_Fabrication_and_Makerspaces_Reconfiguring_Relocating_and_Recalbirating_Innovation/file/60b7d529188536e47c.pdf

Sol, E.-J. (2015). *Factories 4.0 Europe: A vision for the future of manufacturing in Europe as the result of the 4th industrial revolution*. Eindhoven.

Srnicek, N. (2017). *Platform Capitalism*. Cambridge, UK: Polity Press.

Stangler, D., & Maxwell, K. (2012). DIY Producer Society. *Innovations: Technology, Governance, Globalization*, *7*(3), 3–10. https://doi.org/10.1162/INOV_a_00134

Sun, Y., Lindtner, S., Ding, X., Lu, T., & Gu, N. (2015). Reliving the Past & Making a Harmonious Society Today: A Study of Elderly Electronic Hackers in China. In *Cscw 2015* (pp. 3933–3942). Vancouver. https://doi.org/10.1145/2675133.2675195

Sundararajan, A. (2016). *The Sharing Economy*. Cambridge, MA: The MIT Press.

Tabarés-Gutiérrez, R. (2015, July 29). *La Belleza del Código: Influencia de la Web 2.0, los medios sociales y los contenidos multimedia en el desarrollo de HTML5*. Universidad de Salamanca. Retrieved from http://dsp.tecnalia.com/handle/11556/190

Tabarés-Gutiérrez, R. (2016). Approaching maker´s phenomenon. *Interaction Design and Architecture(s)*, (30), 19–29.

The Economist. (2012). A third industrial revolution. Retrieved May 12, 2014, from http://www.economist.com/node/21552901

Turner, F. (2006). *From Counterculture to Cyberculture: Stewart Brand, the Whole Earth Network, and the Rise of Digital Utopianism*. Chicago: University of Chicago Press.

Verniere, P., Van der Straeten, J., Torfs, D., Venderlinden, S., & Van den Kerkhof, G. (2017). *Industry 4.0: hype or reality? The current state of play in Flemish manufacturing*.