D6.3 LEGAL PRACTICES OF DIDIY HARDWARE TECHNOLOGIES – CASE STUDIES

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Executive summary

We select a series of cases that we consider as so called "good practices" that can be useful or inspiring for other projects to learn from. We place the legal aspects in a broader perspective of Digital DIY communities seeking for a sustainable organising model, or an "open business model". Our framework has seven main pillars, including licensing, revenue models, production models, governance, community co-creation, external regulatory framework and impact. We look at some cases that provide a platform for the sharing of knowledge and designs, projects that produce machines and projects that produce open (source hardware) designs. Last but not least we also present some cases which run a community network and others that make use of them, collaboratively producing and using open data as a data commons. All cases are examples of Digital DIY that maximise the potential for replication, reuse and modification. We hope these cases to inspire and illustrate some of the challenges and ways in which communities have found to deal with them seeking ongoing sustainability of their individual and collective projects.

After its formal release, updated versions will be made when possible and relevant.

Revision history			
Version	Date	Created / modified by	Comments
0.0	25/01/17	FKI	Draft outline.
0.1	15/01/17	FKI	First incomplete draft.

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Introduction

This document is especially directed at policymakers, practitioners, educators, activists, NGO's and companies interested in Digital DIY. Digital DIY is a socio-technical phenomenon. For it to thrive we need to take into account a multidisciplinary approach. When analysing legal practices of technological projects, we should not only look at the licensing and other legal aspects, but place it in a larger context. We suggest to take an integral view, considering that this phenomenon is part of a larger socio-economic change, or transition. What is particularly relevant is to see inspiring practices of projects and communities that apparently are pioneering this recent phenomenon and successfully so to some extent. We'll want to know how come they can share knowledge under open or even free licenses while still being able to sustain the costs related to the project. Such projects run the risk of being replicated (forked). How come the community is not walking away to some other (forked) project? How does the community influence strategic decisions, or in other words: what governance model do they follow? These and other questions we try to answer for each case, in a structured set of case studies.

1.2 Terms and acronyms

DIY	Do It Yourself
DiDIY	Digital Do It Yourself
ABC	Atoms-Bits Convergence
IoT	Internet of Things
RT	Research Topic
IPR	Intellectual Property Rights
Free	Adjective from the noun "freedom", as used in "free speech"; in the context of digital works it refers to works that anyone is allowed to use for any purpose, to modify, share and distribute modified versions of that work; for clarity's sake sometimes "free as in freedom" is used
Gratis	Adjective that refers to something that is "free of charge", without a price (but can have a cost)
Libre	Adjective from Spanish meaning "free as in freedom" used to refer to "free" in an unambiguous way; the use of this term highlights the fact that only the English language has the ambiguity of free as in freedom and free of charge
Open	Adjective that refers to unimpeded access (cf, "open door")

Open Source	Adjective that refers to unimpeded access to the source files of a work, enabling anyone to use them for any purpose, to modify, share and distribute modified versions of that work; access to the source code is a precondition for this
FLOSS	Acronym for "Free/Libre Open Source Software" first used for a research project by that name; later used to refer to the full ecosystem of free, libre and open source software projects (likewise the FLOK Society project in Ecuador refers to Free/Libre Open Knowledge Society)
Business model	A business model "describes the rationale of how an organization creates, delivers, and captures value, in economic, social, cultural or other contexts", [Osterwalder, 2010].

A framework for analysing Open, Commons-oriented Business Models

As innovation is changing in the age of the Internet, Henry Chesbrough came with the term "Open Innovation" to point out that "valuable ideas can come from inside or outside the company and go to market from inside or outside the company as well", [Chesbrough 2003]. This insight required organisations to adopt an "open" model of innovation. In his next book, Open Business Models, he shows how to make money in this new landscape, by managing intellectual property differently [Chesbrough 2006]. However Chesbrough's notion of such business models wasn't at all about "open source" (or Libre Innovation as some call it), in that controlling IPR was still key in his thinking.

Since the 1980s the Free Software Movement showed a practical way to build valuable projects and thriving businesses based on sharing their contributions freely, as a radical form of Open Innovation, also referred to as: Libre Innovation. Business models in Free Libre Open Source Software (abreviated FLOSS) have been studied first by the FLOSS project, [Rishab Gosh, 2001] pointing to models of dual licensing, selling professional services, selling of branded merchandise, selling of certificates and trademark use, selling software as a service, project grants from public or private sources, voluntary donations, bounty-driven development, pre-order/crowdfunding/reverse-bounty model, advertising supported software, selling of optional proprietary extensions (also called "open core"), open-sourcing on end-of-life, and others[1].

Since 2001, Creative Commons added a simple range of generic licenses, which range from completely free (permissive: BY) to copyleft (BY-SA) to non-free licenses with restrictions on commercial use or derivatives. The licenses offered by Creative Commons are considered "open licenses".

Open Business Models then have come to mean those models that encourage sharing of knowledge under open licenses, from free to some rights reserved. Paul Stacey and Sarah Pearson worked with Creative Commons to publish a crowdfunded ebook about it in 2015: "Made With Creative Commons – Open Business Models"[2]. An updated version is expectd in 2017. They detail the following five revenue strategies:

1. **Method #1: Digital to Physical**

2. **Method #2: Direct Connect**

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1 See for a complete list: https://en.wikipedia.org/wiki/Business_models_for_open-source_software
2 https://medium.com/made-with-creative-commons/what-is-an-open-business-model-and-how-can-you-generate-revenue-5854d2659b15#.kx7z6jz49

3. **Method #3: Matchmaking**

4. **Method #4: Value-Add Services**

5. **Method #5: Members**

In the cases they studied they observe that projects typically combine different methods.

But a business model is much more than just the licensing and the revenue model. Granted that these two are often already a challenging first set of variables to solve, a business model "describes the rationale of how an organization creates, delivers, and captures value, in economic, social, cultural or other contexts", [Osterwalder, 2010].

Professor Yochai Benkler coined the term commons-based peer production (CBPP), (Benkler 2002), which describes a new model of socioeconomic production in which large numbers of people work cooperatively (usually over the Internet). Commons-based projects generally have less rigid hierarchical structures than those under more traditional business models. Often—but not always—commons-based projects are designed without a need for financial compensation for contributors.

Benkler distinguishes three main economic production models:

1. intrafirm or inhouse production: paid staff inside an organisation realise the production – typically in an hierarchical setting

2. market production: buy the product or service in the market

3. peer production: peers are freely participating in the production of a good or service

Benkler came to define peer production after years of observing various Internet communities, changing the news landscape through the introduction of blogs, people voluntarily contributing their excess computer capacity to the SETI@home research project, volunteers producing GNU/Linux and later Wikipedia. When the resulting good (of peer production) can be considered a (digital) commons, one can speak of Commons-based peer production. This third mode of production - as Michel Bauwens calls it, (Bauwens 2006) - can be appreciated in many Digital DIY communities, such as the ones we will discuss in this report.

With the EC funded P2Pvalue project we have researched over 300 online communities of various categories to establish some 150 indicators and variables for comparison. We looked into community platform tools to facilitate engagement, governance structures, revenue models, licensing etc.

All these preceding studies have led us to develop the following Open/Commons Business/Sustainability framework for analysing how and why projects reach sustainability. In some

cases having a fully peer production oriented platform without monetary costs for operation may make a project sustainable, while others do generate revenue and are able to have a team of salaried workers to maintain the core operation of a project. In all cases there seems to be a fragile equilibrium between the motivations of different stakeholders: the challenge seems to lie in maximising the motivation of a sufficiently large group of people to peer produce important parts of the project with an alligned policy on sharing knowledge and governance.

When looking at open, commons-oriented business or sustainability models we consider as its main pillars or axis: 1) **licensing schemes** that allow reuse and modification, 2) **revenue models** not focused on selling licenses, compatible with point 1; 3) **modes of production**, where peer production can bring the costs down (to a project); 4) **governance models**. We could add the relations with external **regulatory frameworks** (local, national and international laws and regulations) and look at **impact** as well.
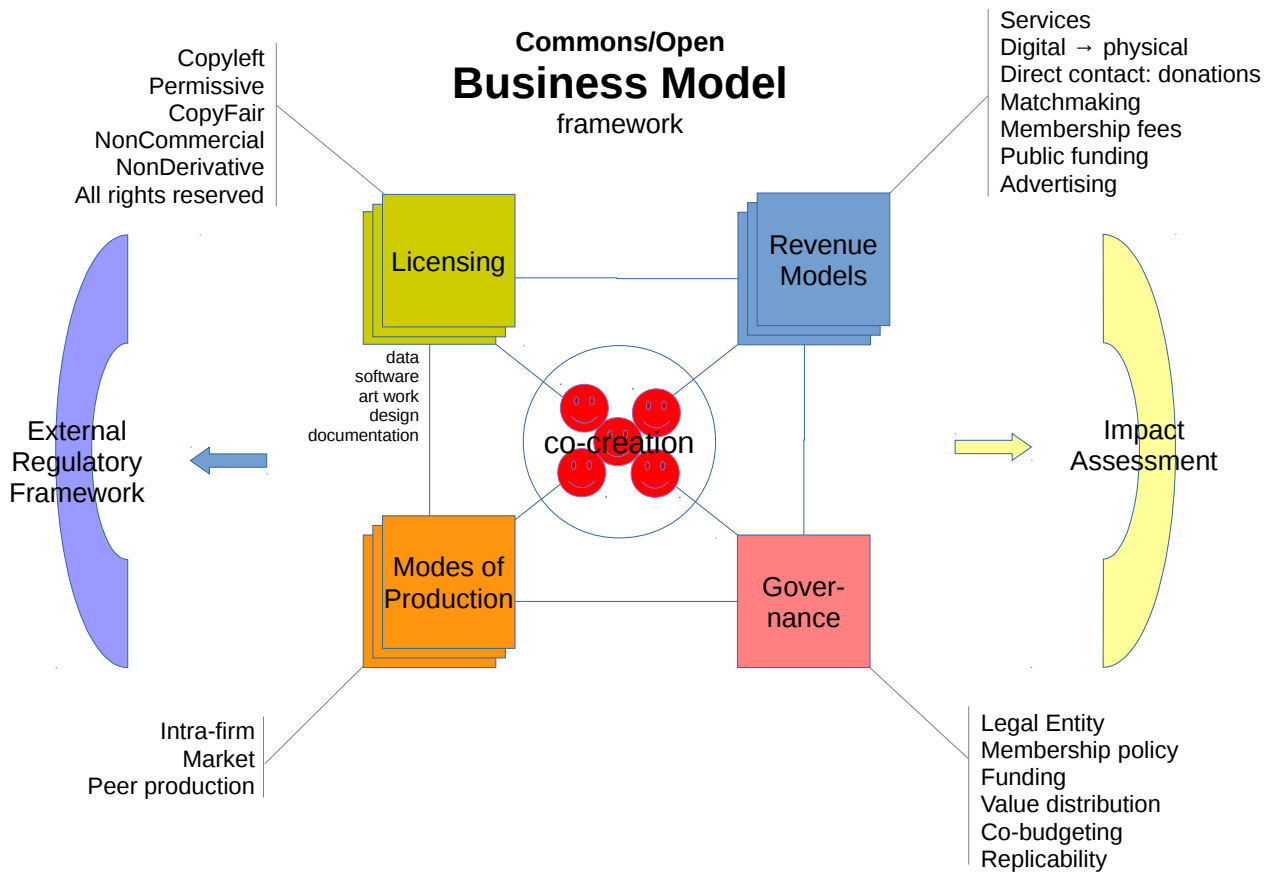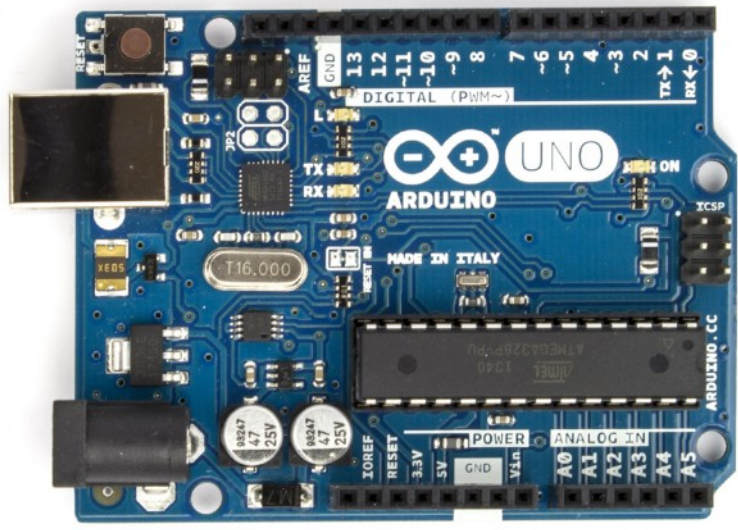
Many projects are composed of a variety of elements that can each have its internal regulations: there can be software, documentation, artwork and design, data or brand which all come with different conditions and production models. Take a project like OpenDesk: the furniture designs offered on its platform are under open licenses, but the software that runs the platform is proprietary and not shared with the community. The result is that this project cannot be easily replicated and contributors depend fully on the legal entity behind it. The designs can be reused under non-commercial conditions, thereby limiting commercial revenue models.

A case like Arduino shows a rather different approach, where the electronics boards itself is under a free license, which can be fully replicated, and that happens by individuals and companies alike, competing with the official products by the founder's company.

Case Studies

Case: Arduino

Case	*Arduino* *http://arduino.cc* *open-source electronics platform for sensing and actuating*
Description	Arduino is a project that develops electronic microcontroller boards for interacting with sensors and actuators and control the related information through networks. It started in 2005 in the Institute for Interaction Design in the Italian city of Ivrea. Teachers of the school considered the need of their students to low-cost microcontrollers, of which there we none at the moment and decided to develop a project of their own. They then decided to share the designs so others could make derivatives and improvements freely. This strategy worked and in following years a fast growing community emerged around the project. Arduino and Arduino-compatible boards use printed circuit expansion

Case	**Arduino**
	http://arduino.cc
	open-source electronics platform for sensing and actuating
	boards called shields, which plug into the normally supplied Arduino pin headers. Shields can provide motor controls for 3D printing and other applications, Global Positioning System (GPS), Ethernet, liquid crystal display (LCD), breadboarding (prototyping) or be made according to one's own needs.
Community	The Arduino community has as its main community platform the Arduino.cc website. It contains the official documentation and learning resources, a forum, online shop, personal profile, karma points, direct personal messaging, unified account management and allows connections to 3rd party platforms. Software development takes place through the github repository at https://github.com/arduino/. Additionally the community self organises through Arduino meetups and workshops at makerspaces around the world. The community makes both derivatives and extensions (shields) to the official Arduino products.

Licensing	All explicit knowledge is shared under free licenses:
	• content, documentation and designs under CC BY-SA 3.0
	• software (derived from Processing and Wiring):
	   ○ GNU General Public License (GPL)
	   ○ GNU Lesser General Public License (LGPL)
	The Arduino name is exclusively protected by trademarks owned by the founders and their respective companies. Use of the Arduino name is to be negotiated with its owners. Two general licensing programmes are in place and require fees to be paid:
	• Arduino Certified[3] for derivative products
	• Arduino AtHeart[4] for products that incorporate Arduino

Revenue models	• Arduino sells physical versions of their design through their online shop and a network of distributors – these are official Arduino products and come with quality assurance by the founders • legal replicas are available in the market (legal, given it's free license of the designs), often at much lower costs that the official

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3 https://www.arduino.cc/en/ArduinoCertified/Products
4 https://www.arduino.cc/en/ArduinoAtHeart/Products

Case	**Arduino** *http://arduino.cc* *open-source electronics platform for sensing and actuating*
	products (cf. an official Arduino Uno may cost 20€, while Chinese versions are available for around 3€) • despite the higher cost of the official products, many people buy the official, thereby supporting the core team for its work • licensing fees for partners in the Arduino Certified or Arduino AtHeart programmes • training, conferences and consultancy
Modes of production	The original Arduino hardware was produced by the Italian company Smart Projects from one of the Arduino cofounders. Some Arduino-branded boards have been designed by the American companies SparkFun Electronics and Adafruit Industries. As of 2016, 17 versions of the Arduino hardware have been commercially produced. Additionally several companies produce unofficial versions (replicas) and in many makerspaces people produce their own selfmade Arduino boards, with some help of the local community.
Governance models	• Arduino.cc and core community infrastructure is owned by the foundation, Arduino AG, while global distribution under the Arduino brand is controlled by the Arduino Holding (see more in Other below). • The governance model is the so called "Benign Dictatorship" model[5]: the community continues to support the leadership of the founders as long as they are dominantly perceived as being useful for the progress of the collective project. • Replicability: the whole project can be replicated, which is done by both small community groups at local makerspaces as well as by manufacturers. This replicability keeps the project leaders honest: as long as they work for the common good of the community, these may stick with them, otherwise they may go to a "fork" or alternative project.

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5   Known from many successful Free Software projects, see
https://en.wikipedia.org/wiki/Benevolent_dictator_for_life

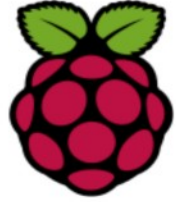| Case	Arduino http://arduino.cc open-source electronics platform for sensing and actuating
Indicators of impact	- Number of sales: according to Arduino co-founder David Cuartielles they have a global community of approx. 110 million users. - Arduino is used in many DIY products, like in 3D printers such as RepRap - Number of community groups and meetups around the world - Google Incoming Links (Arduino.cc): 3.690.000 - Alexa Global Rank (Alexa.cc): 2.631
Other	One of Arduino's founders managed to secretly obtain some of the trademarks for his own company (Smart Projects SRL) exclusively and don't bring it into the shared company, Arduino LLC. That company was then renamed into Arduino SRL and stopped collaboration with the other founders. This has led the latter to continue the core project with two brand names: Arduino and Genuino to continue global distribution[6], [7]. In 2016 however both Arduino companies reached a settlement[8] and have created the Arduino holding as the single point of contact fro distribution and the Arduino AG foundation for hosting the community.

Case: Raspberry Pi

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[6]   http://makezine.com/2015/03/19/massimo-banzi-fighting-for-arduino/
[7]   http://hackaday.com/2015/03/12/arduino-v-arduino-part-ii/
[8]   https://globenewswire.com/news-release/2016/10/01/876280/0/en/Two-Arduinos-Become-One.html
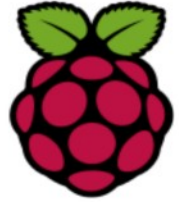
Case	**Raspberry Pi** **https://www.raspberrypi.org/** **A small, powerful and lightweight ARM-based computer.**
Description	The Raspberry Pi is a series of small single-board computers developed in the United Kingdom by the Raspberry Pi Foundation to promote the teaching of basic computer science in schools and in developing countries. The original model became far more popular than anticipated, selling outside of its target market for uses such as robotics. The first version was distributed in 2012.
Community	The community organises through a plethora of online spaces, being the official website the most prominent one: https://www.raspberrypi.org/ It consists of the official documentation and learning resources, a community forum, blog and download section. Community gatherings and hackatons are organised as "Pi Jams", while also many Raspberry Pi meetups and educational workshops are organised.
Licensing	The Raspberry Pi designs itself are proprietary and exclusively owned by the foundation, although the diagrams have been published. Only partners are allowed to manufacture the products. The software is mostly free software: the official Raspbian operating system is derived from Debian Linux (GPLv2). However proprietary drivers are included free of charge for the Broadcom chipset. The documentation is under a free license: Creative Commons Attribution ShareAlike.
Revenue models	• Royalties from hardware sales through contract manufacturer RS Components[9] and its distributor network. • Donations[10] • Education and training programme through the PiCademy
Modes of production	Tthe hardware is designed by the foundation and produced and distributed by contract manufacturer RS Components. The Foundation runs a distributor network. The software is mostly developed by the community, on top of the Debian Linux operating system. On top of that the community designs and shares shields, or 'HATs' (Hardware Attached on Top).

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9   http://uk.rs-online.com/web/generalDisplay.html?id=raspberrypi
10   https://www.raspberrypi.org/about/supporters/

Case	*Raspberry Pi* *https://www.raspberrypi.org/* *A small, powerful and lightweight ARM-based computer.*
Governance models	• The project is owned and governed by the Raspberry Pi Foundation, which in turn is governed by a Board of Trustees, supported by members[11].
Indicators of impact	• Sales: According to the Raspberry Pi Foundation, over 5 million Raspberry Pis have been sold before February 2015, making it the best-selling British computer. By the 9th of September 2016 they had sold 10 million. • Google Incoming Links (raspberrypi.org): 4.140.000 • Alexa Global Rank (raspberrypi.org): 2.963
Other	Although RPi is low-cost and a non-profit community project and most of its software and documentation under free licenses, the hardware designs themselves are non-free and not open source at all. This fact was observed for example by South-Corea based manufacturer Hardkernel interested in bringing a modified version (called Odroid) on the market with certain enhancements: more features in a much smaller board[12]. RPi works with chipmaker Broadcom who decided to stop providing Hardkernel with the Broadcom System-on-a-Chip[13]. This forced Hardkernel to stop the sale of Odroid.

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11 https://www.raspberrypi.org/about/governance/
12 http://www.hardkernel.com/main/products/prdt_info.php?g_code=G140610189490
13 http://www.theinquirer.net/inquirer/news/2362800/hardkernel-cancels-raspberry-pi-like-odroid-w-after-broadcom-stops-supplying-soc

Case: C.H.I.P.

Case	C.H.I.P. *https://getchip.com/* The world's first 9$ computer!
Description	CHIP (stylised as C.H.I.P.) is a personal single-board computer created by Next Thing Co., initially released on Kickstarter[14]. It is advertised as "the world's first $9 computer". Its Kickstarter campaign was successfully funded in May 2015, which had started with a goal of $50,000 USD and ended with 39,560 backers pledging $2,071,927. The system is built around the System on a Chip processor R8 from AllWinner and packs an amazing number of features into a small and documented Open Source Hardware project.
Community	Documentation: https://docs.getchip.com/chip.html Forum at: https://bbs.nextthing.co/ A dedicated section at the Hackster.io web platform to encourage the community to share their projects based on CHIP: https://chip.hackster.io/
Licensing	The hardware designs, schematics and PCB layouts are published under the CC BY-SA v3 license: https://github.com/NextThingCo/CHIP-Hardware/. The documentation is licensed under a free license: the Apache 2.0 license. The software is based on Debian Linux, under the GPL v2 license.
Revenue models	• Hardware sales through the kickstarter campaign and through the webshop: https://getchip.com/pages/store • apparently chip manufacturer Allwinner has a strategic stake in the

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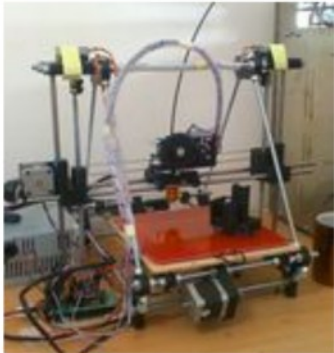14 https://www.kickstarter.com/projects/1598272670/chip-the-worlds-first-9-computer/

Case	***C.H.I.P.*** ***https://getchip.com/*** ***The world's first 9$ computer!***
	project to help it become a platform with many users, that will need the Allwinner chips; • custom development, consultancy and training.
Modes of production	While the Next Thing Co. team works from Oakland (California), the manufacturing is contracted in Shenzen (China). Summarising, part of the development work takes place inhouse (intrafirm), while other parts are done by peers in the community and the material production is contract manufactured (market based). Next Thing Co. is a startup that came out of the HAXLR8R acceleration programme[15] and previously run another successful kickstarter for their OTTO camera module.
Governance models	• The company Next Thing Co. is the owner and leader of the project. • the project is documented under free licenses and is replicable. This is presented as a powerful feature allowing others to build derived products on top of it, without requiring any Non-Disclosure Agreement or special permission.
Indicators of impact	• Almost 40.000 backers at kickstarters • millions of C.H.I.P.'s sold in the first • 23 employees by November 2016[16] • Google Incoming Links (http://getchip.com/): 117.000 • Alexa Global Rank (http://getchip.com/): 72.429
Other	

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15 https://hax.co/companies/next-thing-co/
16 http://www.mercurynews.com/2016/02/08/for-oakland-startup-a-9-computer-about-more-than-getting-rich/

Case: RepRap

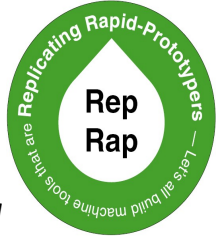| Case	*RepRap*
	http://reprap.org/ *Let's all build machine tools that are Replicating Rapid-Prototypers*
Description	*These are three illustrations of the many RepRap designs[17]:* *Illustration 1: Prusa Mendel* *Illustration 3: Prusa i3 Rework* *Illustration 2: Micro Delta* The RepRap project started in England (by Adrian Bowyer, in 2005) as a University of Bath initiative to develop a 3D printer that can print most of its own components and be a low-cost 3D printer, but it is now made up of hundreds of collaborators world wide. RepRap is short for replicating rapid prototyper. The RepRap was possible after the expiration of the patent on Fused Deposition Modelling (FDM), the core technique of printing small drops of molten plastic. The RepRap evolved from a first prototype in 2006 to v1.0 (called "Darwin") in 2008, v2.0 ("Mendel") in 2009. 2010 saw the third generation, called "Huxley" and in 2012 the first Delta printer was built, called "Rostock".
Community	RepRap has been conceived as a complete replication system rather than simply a piece of hardware. To this end the system includes computer-aided design (CAD) in the form of a 3D modeling system and computer-

17 http://reprap.org/wiki/RepRap_Machines

Case	**RepRap** **http://reprap.org/** *Let's all build machine tools that are Replicating Rapid-Prototypers*
	aided manufacturing (CAM) software and drivers that convert RepRap users' designs into a set of instructions to the RepRap hardware that turns them into physical objects. The core community space is the RepRap wiki at http://reprap.org/. Core online community spaces include forums, IRC channels, blogs, while physical spaces are listed under the RepRap User Groups, that provide local hubs for RepRappers, such as hackerspaces and makerspaces.
Licensing	The content on the RepRap.org wiki is under a free license: GNU FDL. The RepRap itself is under the GNU GPL[18], while different machine designs – by different members – are under different licenses: http://reprap.org/wiki/RepRap_Machines.
Revenue models	• Donations • Each participant may have its own income strategies, as the following cases will demonstrate.
Modes of production	Community members either built their own RepRap from scratch, with help from other members (who already have a machine to replicate the necessary parts), buy a kit for self assembly or acquire a fully assembled product. It is worth noting that RepRaps builts on top and include various other Open Source Hardware and Free Software projects, such as Arduino.
Governance models	• Ownership of contributions lie with the individual contributors. There is no central organisation holding control over the community.
Indicators of impact	• RepRap was the first of the low-cost 3D printers, and it can be argued that the project started the open-source 3D printer revolution. It has become the most widely-used 3D printer among the global members of the Digital DIY culture and maker community.

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18   http://reprap.org/wiki/RepRapGPLLicence

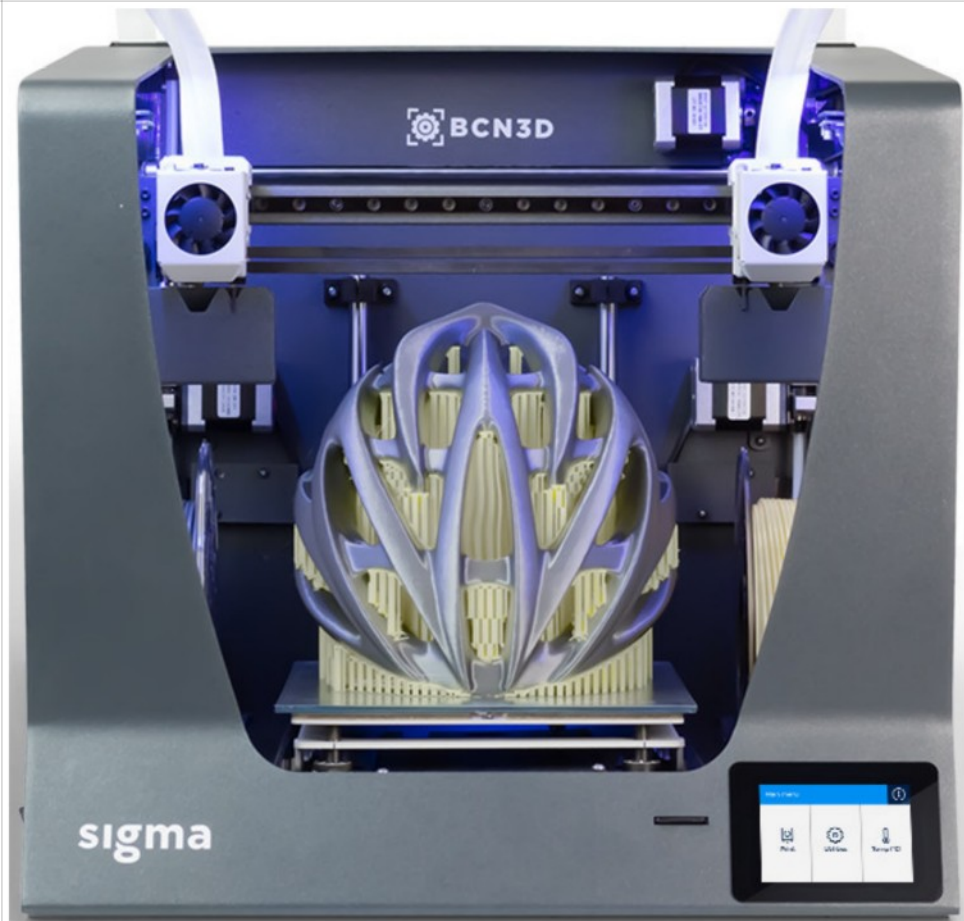| Case	*RepRap*
	http://reprap.org/
	Let's all build machine tools that are Replicating Rapid-Prototypers
	• Google Incoming Links (http://reprap.org): 147.000 • Alexa Global Rank (http://reprap.org): 21.092
Other	The RepRap project states: "RepRap makes every effort not to use patented technology, and we encourage people to publish all their RepRap ideas and inventions to prevent their being patented by others. (This is what's known as establishing prior art.) Good places to publish are this Wiki (which automatically date-stamps and records any edits) or possibly Defensive Publications. The patenting of 3D-printing (and other) inventions inhibits their free development and exploitation. The Open Invention Network (OIN) was started by individuals, organisations and companies to free existing patents and to prevent known or obvious ideas from being patented. RepRap is not a member of OIN (RepRap is too nebulous and diverse a group of people to be a member of anything). But if individuals, organisations and companies working with RepRap wish to join, that is entirely in line with RepRap principles and ideals. People may also care to promote the idea of Free Patents. Finally, some people have taken open inventions and tried to patent them. When a patent application is submitted people have a right and a duty to object to it if they know that the invention is already in the public domain. A useful website if you want to help with this effort is Ask Patents, the idea for which is described here."

Case: RepRap Barcelona / BCN 3D Technologies

Case	*BCN 3D Technologies* *https://www.bcn3dtechnologies.com/* *Open Source Digital Fabrication Machines made in Barcelona*
Description	 Barcelona 3D Technology is a project from the Fundació CIM to design and create domestic and professional 3D printers in a way that the user can learn with every print, thanks to their Open Source working method. The project started as RepRap Barcelona and has gone through a series of iterations of RepRap 3D printer designs and in 2016 added a DLP printer and Laser cutter to its catalog. It benefits greatly from the foundation

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Case	*BCN 3D Technologies*
	https://www.bcn3dtechnologies.com/
	Open Source Digital Fabrication Machines made in Barcelona
	being part of the technical university, running an advanced manufacturing facility, master programme and various hands-on workshops in digital fabrication.
Community	The main software and design repository is at github: https://github.com/BCN3D while there are online forums on their own website. Physically the foundation runs a series of municipal FabLabs for the BCN City Council, participates in digital fabrication events and offers workshops at their own facilities.
Licensing	The hardware designs of the last generation of machines, in particular the SIGMA, are under the CERN Open Hardware License, while the BCN 3D+ is under the MIT license..
Revenue models	- Sale of hardware, in the form of kits, finished products and spare parts, both through their online shop as through a distributor network - Consultancy, prototyping and small scale custom made products - Course programmes and workshops - Technical support and coordination of makerspaces
Modes of production	Inhouse production of the machines and testing equipment with sourced materials and components from local and regional providers. The manufacturing process itself is considered a learning experience for the UPC students. The R&D and designs benefit from peer production globally shared experiences and designs of improvements in the RepRap community in particular and digital fabrication machine designers in general.
Governance models	- The project is part of the Foundation CIM, liaised with the technical university of Catalonia, UPC: https://www.fundaciocim.org/ - replicability: the earlier designs were easier to replicate than the last machine series
Indicators of impact	- In 2016: the foundation had 80 persons as staff + ca. 80 students - Machines sold:

Case	*BCN 3D Technologies* *https://www.bcn3dtechnologies.com/* *Open Source Digital Fabrication Machines made in Barcelona*
	• Google Incoming Links (bcn3dtechnologies.com): 15.100 • Alexa Global Rank (bcn3dtechnologies.com): 397.116
Other	

Case: RepRap - Lulzbot

Case	*Lulzbot*
	https://www.lulzbot.com/
	We believe you should be free to use, learn from, and improve the machines you use, and share that with the community.
Description	

The Lulzbot printers are developed by the small company Aleph Objects, Inc. which is committed to Free Software, Libre Innovation, and Open Source Hardware. Although the printers include some extruded aluminum railing and other mass-production components it still remains true to RepRap principles by having many components 3-D printable.

Due to its fully Open Source Hardware and Free Software design, the LulzBot has received the "Respects Your Freedom" certification from the Free Software Foundation. In addition, the Lulzbot printers are often used

Case	*Lulzbot*
	https://www.lulzbot.com/
	We believe you should be free to use, learn from, and improve the machines you use, and share that with the community.
	in open-source tool chains on open source projects.
Community	The development, assembly and use of the Lulzbot machines is facilitated by an online community forum, a project development platform (Phabricator). There's also the Open Hardware Assembly Instructions.
Licensing	"Aleph Objects, Inc. — Committed to Free Software, Libre Innovation, and Open Source Hardware LulzBot® and the LulzBot logo are registered trademarks of Aleph Objects, Inc. All site content, unless otherwise noted, is licensed CC BY-SA 4.0 International by Aleph Objects, Inc." Some of the hardware designs are under the GNU GPLv3, while others are under a CC BY-SA license, all respecting the four freedoms.
Revenue models	• Sale of physical products built from the Open Source Hardware designs, spare parts, accessories and filament through their online store and a global network of distributors. • Educational programme, for price discounts, exclusive bundle options, and more
Modes of production	Aleph Objects produces a large part of their machines inhouse (intra-firm), buying some of the components on the market – such as the mass produced aluminum rails. R&D is led by the company following a Libre Innovation model, where advances are both shared with and contributed by the wider Open Source Hardware and Free Software community.
Governance models	• The project is owned by the company Aleph Objects Inc., founded in 2011. • All digital works produced by the project, as well as the underlying online platforms, are under free licenses and replication is actively encouraged.
Indicators of impact	• Aleph Objects, Inc. ranked No. 122 on Inc. Magazine's 35th annual Inc. 500, the most prestigious ranking of the fastest-growing private companies in the United States. Aleph Objects achieved 2,782 percent three-year sales growth.[19] • The Lulzbot TAZ 6 3D printer is recognised by the Free Software Foundation with the "Respects Your Freedom" certification, the

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19   https://www.lulzbot.com/learn/announcements/lulzbot-parent-company-ranks-122-inc-500-list

Case	*Lulzbot*
	https://www.lulzbot.com/
	We believe you should be free to use, learn from, and improve the machines you use, and share that with the community.
	10th product by Aleph Objects to receive this certification.[20] • Google Incoming Links (lulzbot.com): 408.000 • Alexa Global Rank (lulzbot.com): 105.551
Other	The company encourages cloning: "For those wanting to use our hardware designs and/or software packages, Aleph Objects requires you to: • Label the product as a clone. It must be clear that it is not a product from our factory. • Note that "LulzBot is a registered trademark of Aleph Objects, Inc." • Host your own copy of the source files on your own server or similar, even if they are unmodified. Do not just point to our existing source. And of course, let us know about your project! Email information to support@LulzBot.com."

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20 https://www.fsf.org/news/lulzbot-taz-6-3d-printer-now-fsf-certified-to-respect-your-freedom

Case: GoodEnoughCNC

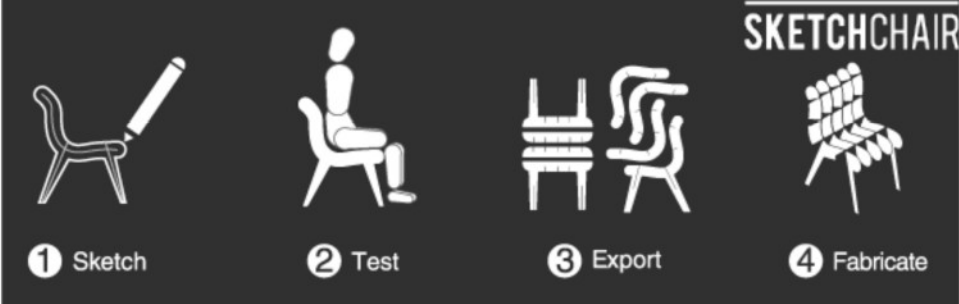| Case	*GoodEnoughCNC* *http://goodenoughcnc.eu/* *Affordable & useful open source CNC machines*
Description	 GoodEnoughCNC is a very low-cost CNC mill built from standard mechanical components and steel profiles. Just basic hand tools are needed for its assembly. It is a hybrid and can be transformed from CNC mill into various other digital fabrication tools, such as a plasma cutter, spindle or laser cutter. It is modular and fully Open Source Hardware.
Community	At the project's website extensive documentation can be found for self-assembly, replication or adaptation. Source files are published through the foundation's github repository[21].
Licensing	At the IRNAS foundation's website the fully free and open source licensing is defined[22]: • "Hardware including documentation is licensed under CERN OHL v.1.2. license.

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21   https://github.com/IRNAS
22   http://irnas.eu/license.html

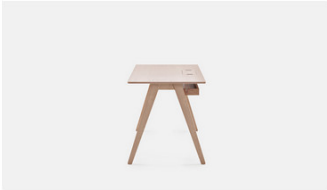| Case	*GoodEnoughCNC* *http://goodenoughcnc.eu/* *Affordable & useful open source CNC machines*
	• Firmware and software originating from the project is licensed under GNU GENERAL PUBLIC LICENSE v3. • Open data generated by our projects is licensed under CC0. • All our websites and additional documentation are licensed under Creative Commons Attribution-ShareAlike 4 .0 Unported License What this means is that you can use hardware, firmware, software and documentation without paying a royalty and knowing that you'll be able to use your version forever. You are also free to make changes but if you share these changes then you have to do so on the same conditions that you enjoy. Koruza, GoodEnoughCNC and IRNAS are all names and marks of Institut IRNAS Rače. You may use these names and terms only to attribute the appropriate entity as required by the Open Licences referred to above. You may not use them in any other way and in particular you may not use them to imply endorsement or authorization of any hardware that you design, make or sell."
Revenue models	• Sale of kits or finished products based on the Open Source Hardware designs • One-day and one week workshops • Donations and grants
Modes of production	Products are made inhouse or by its users through the workshops, based on readily available, low-cost materials and components.
Governance models	• The IRNAS Foundation owns the project • The project is fully replicable due to its licensing, documentation and choice of materials and components.
Indicators of impact	• The project has received a grant from the Shuttleworth Foundation, supporting the work of the project's founder, Luka Mustafa. • Google Incoming Links (goodenoughcnc.eu): 1.140 • Alexa Global Rank (goodenoughcnc.eu): 669.984
Other	

Case: SketchChair

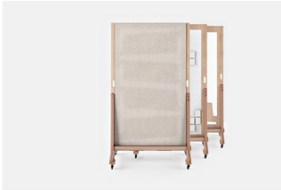| Case	**SketchChair** http://sketchchair.cc/
Description	SketchChair is a free software (a.k.a. open source) tool that allows anyone to easily design and build their own digitally fabricated furniture. Within the program, you can upload chairs you have created, adding them to a growing collection of open-source designs in the SketchChair Design Library. Any of these chairs are freely available to be downloaded and edited by anybody, allowing chair designs to evolve as users continually refine and modify them.
Community	There is a wiki for instructions of use and a design library for sharing designs made with the tool. The software's source code is at their github repository[23].
Licensing	Many of the designs in the library are under a non-free open license: CC BY-NC-SA. The software is under the GNU GPL.
Revenue models	• They ran a successful Kickstarter campaign (2011) for the initial development • Voluntary donations through their user registration page • Custom development
Modes of production	Do it yourself and peer production.
Governance models	• The project is owned by Diatom Studio Ltd: http://diatom.cc/
Indicators of impact	•

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23   https://github.com/DiatomStudio/SketchChair

Case	*SketchChair* *http://sketchchair.cc/*
	• Google Incoming Links (sketchchair.cc): 14.600 • Alexa Global Rank (sketchchair.cc): 1.671.413
Other	

Case: OpenDesk

Case	*OpenDesk* *https://opendesk.cc/* ***Designed to be downloaded and made locally, Opendesk furniture is fast, affordable, sustainable and made on demand, just for you.***
Description	 Lean Desk Studio Desk Divide Meeting Table Unit Table Team Desk OpenDesk is a platform where you can find customisable furniture designs, for a Digital DIY'er to download and make, request a designer to customise and a local maker to produce the desired product.
Community	The OpenDesk team selects designers that participate in the official design catalog. Community members can publish their designs in a community section.

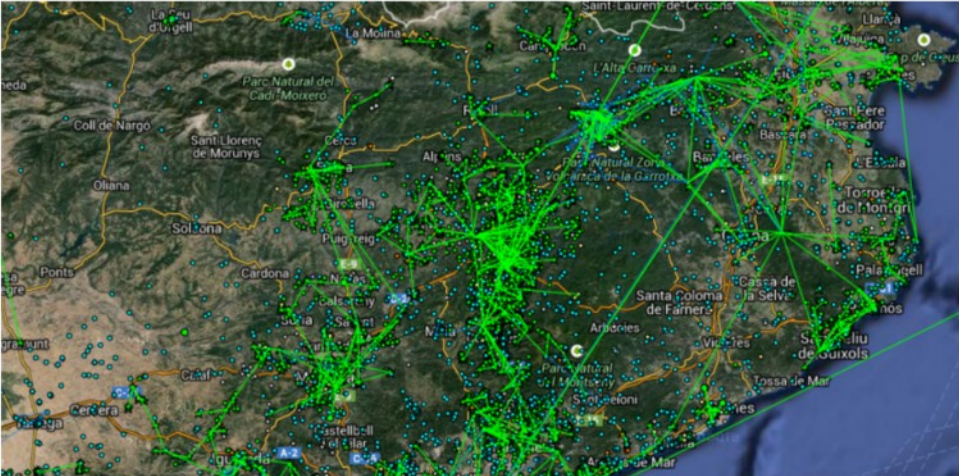| Case	*OpenDesk* *https://opendesk.cc/* ***Designed to be downloaded and made locally,*** ***Opendesk furniture is fast, affordable,*** ***sustainable and made on demand, just for you.***
Licensing	Designs can be downloaded for non-commercial use.
Revenue models	Opendesk is an online platform connecting customers, makers and designers. When *customers* buy an Opendesk product directly from a registered maker they pay the sum of: 1. **manufacturing cost**: fabrication, finishing and any other costs as set by the maker (excluding any services like delivery or on-site assembly) 2. **design fee**: as 8% percent of the manufacturing cost 3. **platform fee**: as 12% percent of the manufacturing cost (OpenDesk) 4. **channel fee**: as 18% percent of the manufacturing cost (OpenDesk) *Designers* who participate sell under your their name and brand and — within the structure of the OpenDesk business model — set their own pricing for commercial and non-commercial use, choose your license terms and retain all the rights to their work, including the right to sell anywhere else. Professional *makers* with access to a CNC workshop, when joining the platform, are granted a commercial license to make Opendesks.
Modes of production	Designs are contributed by the participating designers; local makers produce the desired furniture inhouse in a nearby makerspace or professional fabrication lab.
Governance models	• The project is owned by Fabbed Ltd traded as OpenDesk • the project as such is not replicable but can be used as an inspiration
Indicators of impact	• Google Incoming Links (): • Alexa Global Rank ():
Other	

Case: Wikihouse

Case	*WikiHouse* *https://wikihouse.cc*
Description	WikiHouse is an open source project to reinvent the way we make homes. It is being developed by architects, designers, engineers, inventors, manufacturers and builders, collaborating to develop the best, simplest, most sustainable, high-performance building technologies, which anyone can use and improve. The aim is for these technologies to become new industry standards; the bricks and mortar of the digital age.
Community	Designs are published in the gallery at the website, with the source files at the project's gitHub repository: https://github.com/wikihouseproject
Licensing	Designs are generally published with CC BY SA license.
Revenue models	• Donations • Grants • Pilot projects
Modes of production	Local production of pilot project with the help of makerspaces.
Governance models	• The project is owned by the WikiHouse Foundation, a UK registered non-profit • The project's designs can be replicated and modified freely
Indicators of impact	• WikiHouse has been featured at various events • • Google Incoming Links (): • Alexa Global Rank ():
Other	

Case: Guifi.net

Case	*Guifi.net*
	http://guifi.net **guifi·net** (logo) **Commons Telecommunications Network** **Open, Free and Neutral**
Description	 **guifi·net** is a bottom-up, citizen-driven technological, social and economic project with the objective of creating a free, open and neutral telecommunications network based on a commons governance model. The development of this common-pool infrastructure eases the access to quality, fair-priced telecommunications in general and broadband Internet connections in particular, for everybody. Moreover, it generates a model for collaborative economic activity based on proximity and sustainability. In its core all participating members contribute a piece of infrastructure (antenna, node, supernode, piece of fibre optics, router, ..) to the commons, allow the «right of passage» over that infrastructure, thereby organically building their network (see its evolution at https://guifi.net/en/guifi/menu/stats/growthmap). The network started in 2004 and is especially mature in Catalonia, with over 30.000 buildings connected, some through WiFi or radio links others through fibre optic wires (Fibre To The Home) deployed by the neighbours and local users. Since 2008 guifi·net is, through the guifi·net Foundation, a telecommunications operator registered at the Telecommunications Operators Register run by the Spanish National Market and Competence Comission, participates as an AS (Autonomous System) in the Internet and exchanges traffic at up to 30 Gbps in CATNIX, the Internet Exchange Point (IX) of Catalonia.

Case	Guifi.net http://guifi.net **Commons Telecommunications Network** **Open, Free and Neutral**
	The guifi·net is defined as a free, open and neutral network (**FONN**). Namely: • **open**, to ensure that everybody can connect and be part of the it, without discrimination • **free**, because the network is a common-pool resource, and nobody can take it over exclusively • **neutral**, regarding the contents and the technology
Community	The community consists of local groups, that meet periodically and organise so called «guifi labs», where they help each other and collectively make sure the infrastructure they share works properly. They have a range of online services available to facilitate the community, from mailing lists, forums and blogs to custom made mapping tools where people can register all necessary information about the infrastructure that they contribute to the community network. On top of the common infrastructure members run community services such as a multimedia platform and online TV distribution network; the statistics include: • Total Internet Gateways: **7** direct gateways and **312** proxies • VoiceIP Servers: **13** • FTP or shared disk servers: **31** • Instant Message servers: **4** jabbers and **6** irc servers • Videoconference servers: **5** • Web servers: **53** • Broadcast radios (music): **14** • Mail servers: **4**
Licensing	Guifi.net has developed its own community network license: the The Compact for a Free, Open & Neutral Network (FONN Compact) License[24]. It is inspired in the free and open networks principles. In summary: • You have the freedom to use the network for any purpose as long as you don't harm the operation of the network itself, the rights of

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24 https://guifi.net/en/FONNC

Case	Guifi.net http://guifi.net Commons Telecommunications Network Open, Free and Neutral
	other users, or the principles of neutrality that allow contents and services to flow without deliberate interference. • You have the right to understand the network and its components, and to share knowledge of its mechanisms and principles. • You have the right to offer services and content to the network on your own terms. • You have the right to join the network, and the obligation to extend this set of rights to anyone according to these same terms. This license incorporates the lessons learnt from observing many commons governance models from Elinor Ostrom's Institutional Analysis and Development (IAD) framework[25]. The contents of their website are under CC BY-NC-SA. The software used is all under free licenses. The hardware used in the network ranges from proprietary of the shelf routers to open source hardware machines, all documented by the community.
Revenue models	• Donations of two kinds: 1) donations to the foundation, as «friend» or «mecenas»; 2) sponsoring the set up of a node • Services from network operators providing guaranteed services on top of the community infrastructure • Cost Compensation between the operators: operators who invest less in the maintenance of the network than they profit from, by selling services to its endusers, will need to compensate the other operators by the year's end (through the Foundation). • Cost sharing of a local subnet and its connection to the CATNIX exchange in Barcelona and traffic pooling for connecting to the global Internet
Modes of production	The core infrastructure is mostly peer produced by citizens with a Digital DIY mindset and partly produced through a self regulated internal market through the operators.
Governance models	• The network is governed in a decentralised fashion, by the local

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25   https://en.wikipedia.org/wiki/Institutional_analysis_and_development_framework

Case	Guifi.net http://guifi.net Commons Telecommunications Network Open, Free and Neutral
	groups, abiding by the Wireless Commons License. • The license foresees a role for the guifi.net foundation for conflict resolution and for overseeing the cost compensation between commercial operators in their network.
Indicators of impact	• European Commission awards guifi.net the first European Broadband Award[26] in the category on innovative model of financing, business and investment (2015). • Right now there are 32.789 working nodes, 35.883 links, 58.946,6 total kilometers of links, 93 last week new nodes and 43 working nodes last week. • Google Incoming Links (guifi.net): • Alexa Global Rank (guifi.net): 718.099
Other	

Case: The Things Network

Case	The Things Network https://www.thethingsnetwork.org/ Building a global internet of things network together.
Description	The Things Network (TTN) is a grassroots community network that sprang up in the summer of 2015 in Amsterdam when ten people and organisations decided to cover the city by placing one antenna for Long Range (LoRaWAN) data connectivity each and connect them to a shared server offering free access to all sensors and actuators.

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26   https://ec.europa.eu/digital-single-market/en/news/five-projects-got-first-ever-european-broadband-award

Case	***The Things Network*** ***https://www.thethingsnetwork.org/*** ***Building a global internet of things network together.***
	The emerging community defined a manifest to assert free access, protection of privacy and anonymity, net neutrality and the use of open protocols[27]. The model was quickly replicated by hundreds of cities and regions around the world, now forming a global community. By the end of 2015 a crowdfunding campaign in kickstarter collected almost 300.000 US$ to develop Open Source Hardware gateways (antennas) and an Arduino derivative with LoRaWAN connectivity built in.
Community	Each local community has a dedicated area on the global website for visualising members, partners and registered antennas («gateways»). Besides there are forums and a wiki to share documentation. Local communities typically get together periodically and have their own autonomy. They can replicate the central infrastructure from Amsterdam or connect to it directly. In the Labs' section people can share their Digital DIY stories of how they use TTN[28].
Licensing	Different software projects are shared under free licenses, MIT, BSD modified etc. But not all software and content has a license applied to it, therefore making its reuse a potential risk, which should be clarified with the Amsterdam founders. The crowdfunded products are promised to be fully Open Source Hardware: the electronics design under the CERN Open Hardware License, the software under the GNU GPLv2 license and all other materials including the casing design and documentation under the Creative Commons Attribution-Share Alike 4.0.
Revenue models	- cost sharing by local community groups or at the international level to cover the central server infrastructure costs - donations, such as to the crowdfunding campaign - hardware sales through the online shop and a distribution network - workshops to set up and work with the network - specialised services, such as consultancy, deployment and

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27 https://github.com/TheThingsNetwork/Manifest
28 https://www.thethingsnetwork.org/labs/

Case	**The Things Network** **https://www.thethingsnetwork.org/** **Building a global internet of things network together.**
	development of connected products
Modes of production	The network is peer produced by its members, forming a self-governed commons. The hardware is in some cases self built as full Digital DIY but in many cases Commercial Off The Shelf products are bought in the market.
Governance models	Though there is a wide diversity of organising models between the different local communities, most communities tend to be loosely organised initiatives, often without an independent legal entity for the community. The founders are in the process of setting up a foundation in Amsterdam for supporting the global community.
Indicators of impact	• Their successfull crowdfunding campaign collected 295,331 USD[29] • At the date of writing 282 communities in 59 countries are listed on the community page[30] • Google Incoming Links (thethingsnetwork.org): 11.500 • Alexa Global Rank (thethingsnetwork.org): 170.995
Other	

Case: UK Flood Network

Case	**UK Flood Network**
Description	UK Flood Network, uses The Things Network as commons data

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29 https://www.kickstarter.com/projects/419277966/the-things-network
30 https://www.thethingsnetwork.org/community

Case	*UK Flood Network*
	connectivity + cbpp monitoring and data visualisation
Community	
Licensing	
Revenue models	•
Modes of production	
Governance models	•
Indicators of impact	• • Google Incoming Links (): • Alexa Global Rank ():
Other	

Case: OpenTrons

Case	*OpenTrons* *http://opentrons.com/* *Robots for Biologists*
Description	
Community	
Licensing	
Revenue models	•
Modes of production	
Governance models	•
Indicators of impact	• • Google Incoming Links (): • Alexa Global Rank ():

Case	*OpenTrons* *http://opentrons.com/* *Robots for Biologists*
Other	

Case: FirePick

Case	*FirePick* *www.firepick.org* *Open Source Pick 'N Place Machine*
Description	
Community	
Licensing	
Revenue models	•
Modes of production	
Governance models	•
Indicators of impact	• • Google Incoming Links (): • Alexa Global Rank ():
Other	

Case:

Case	
Description	
Community	

Case	
Licensing	
Revenue models	•
Modes of production	
Governance models	•
Indicators of impact	• • Google Incoming Links (): • Alexa Global Rank ():
Other	

Case:

Case	
Description	
Community	
Licensing	
Revenue models	•
Modes of production	
Governance models	•
Indicators of impact	• • Google Incoming Links (): • Alexa Global Rank ():
Other	

Conclusions and recommendations

Sharing of knowledge

Most cases apply an open or free licensing policy, or at least extensively use free and openly licensed works and could suffer the risk of being replicated. Instead of seeing this possibility as a threat, it can be conceived as a strength: community members would most likely feel more inclined to contribute voluntarily to a project, where its leaders cannot exclusively exploit these voluntary contributions. Free licenses give all members basically the same rights and if the way a community is governed doesn't satisfy a sufficient part of the community, this part may consider to replicate or fork the project and continue under an other name.

Mixing revenue streams

While people could engage in full Digital DIY, not all people are willing to do that, for all their activities all the time. Instead people may engage in some Digital DIY activities while satisfying other needs through the market, through non-digital forms of production or otherwise. The cases studied here are examples that enable full Digital DIY but also offer ready made products that people can buy.

Open Source Hardware allows people to DIY but also to produce a commercial product based on the design. In projects such as Arduino, where there is much attention and interest in buying ready made versions, this freedom to manufacture replicas or derivative products allows therefore competition in the offering of an almost identical product. The case of Arduino shows clearly that people are willing to pay a considerable plus over such replicas, mainly by offering two additional unique selling points: 1) the official Arduinos come with a quality label from the founders of the project; 2) by buying the official, one contributes to the founders appreciating their work and helping them to continue.

Observing the various cases we can see that most combine various revenue streams. Community models often combine voluntary donations with hardware sales and specialised added-value services.

Collaborative making or peer production lowers costs

Digital DIY and peer production are a way to spur innovation through the community at lower costs compared to paying salaries for inhouse development or contracting development n the market. The lowering of costs then reduces the need for revenue streams to make a project sustainable. This core logic is what makes for an open business model, or commons oriented sustainability model. It

seems crucial to align the interests of potential contributers and members to maximise the potential of the community.

Professional services on top of a Digital DIY peer produced community project

Where Digital DIY is in its core a non-commercial activity, we have seen that the selected Open Source Hardware projects are able to combine the peer production and free/open licensing with commercial activities, such as sale of products based on the digitally shared artefacts. Communities are however often seen as unable to provide professional services. This we have seen can be solved by having a dedicated legal entity from the founders or leadership of the community (cf. Arduino) or in a more decentralised vision as a network of different legal entities providing their versions (cf. RepRap). We have also seen how a community can produce a telecom network with the Digital DIY mindset (cf Guifi.net, The Things Network). In the case of Guifi.net it is even shown how guaranteed service levels can be provided by commercial operators working on top of the community network. This seems a model The Things Network and other such community services could replicate.

Digital DIY knows many cases of people setting up electronic measurement systems with sensors and actuators. These can be low-cost and are often not calibrated, therefore reducing the quality of the measurements. In data analysis one could easily draw the conclusion - "Garbage in Garbage out" - that there would be little practical value in such data. But apart from the learning and empowerment that is in the Digital DIY activity itself, knowing the variations of measurements can already be of value, such as the Flood Network in the UK shows. Next iterations of sensor designs can help improve the quality.

Commons reuses Commons and standardised, readily available components

Another detail that can be observed is the fact that most of the selected cases built on already existing forms of digital commons, like Free Software or existing hardware design communities. For exampl, many RepRap printers use Arduino and various Free Software components.

Commons are fragile but digital commons also guarantee future availability

Despite the social value that can come from such projects, we should recognise their fragility. Any commons requires continuous attention, maintenance, nurturing. A community can stop to exist or move on inside another project.

At the same time Digital DIY communities can provide a more solid value to its users or customers, in that the open nature of these communities and its digital artefacts assure that one is not dependent

on one company (which could go out of business). For example one shouldn't be afraid of Arduino products running out of support in the future, as with a copy of the design, software and documentation one can always contract a specialised person or organisation, independent from the fate of the founders of Arduino.

Regulatory framework

When we introduced the open business model framework in the beginning of this report we mentioned a seventh pillar: the regulatory framework and how cases interact with that. Details of challenges of Digital DIY have been worked out in our previous report D6.1. Dominant Legal Challenges And Solutions Practised. We suspect that the individual cases presented here hardly have direct impact on regulations individually. Maybe RepRap could be the exception, in that this project is often considered as having fueled the domestic 3D printer revolution. As such it may influence the view of policymakers in the regulating of digital fabrication and Digital DIY. When combining the cases studied here with the wider ecosystem of Digital DIY projects and communities we could however conclude that the phenomenon as such shows real social value and that different production and governance models are indeed possible. One effect of that maybe that many regulations foreclosing the mainstreaming of Digital DIY have been postponed or avoided alltogether.

Patenting

Finally, some people have taken open inventions and tried to patent them. When a patent application is submitted people have a right and a duty to object to it if they know that the invention is already in the public domain. A useful website if you want to help with this effort is Ask Patents[31], the idea for which is described here[32].

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31 http://patents.stackexchange.com/
32 https://stackoverflow.blog/2012/09/askpatents-com-a-stack-exchange-to-prevent-bad-patents/

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P2Pvalue research on 300+ online collaborative communities

IAD framework by Elinor Ostrom

collective action research

D6.1. Dominant Legal Challenges And Solutions Practised.