Lasersaur: opening objects

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This text represents ongoing work of my PhD project 'Concrete utopias of an open technology. The practices and futures of open design.' Comments and feedback are welcome. For more information on my work and myself and the possibility to contact me please visit my blog: http://im-noch-nicht.de

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Introduction

When I first encountered an assembled Lasersaur in the project's founders home and studio in Innsbruck I was struck by the neat integration of the machine into the living room. The majority of laser cutters normally resides inside industrial workshops, in development departments and some can be found in universities. Laser cutters are typically considered as tools that cut or engrave different materials, they are means of production. While the Lasersaur is capable of this as well and some versions of it can be found in similar places to normal laser cutters, it is strikingly different to its industrial cousins. The Lasersaur is much more than a tool. It is an open source object – a special class of objects that I will elaborate on in this chapter. Everyone can go online and build this machine with the publicly available instructions that the project has created over the last years – even school classes have done this already. In this chapter I will show how this happened in a recursive entanglement in which the object, the community and the knowledge of the Lasersaur were simultaneously created. The Lasersaur, however, is not alone. It is part of a worldwide 'assemblage' (Deleuze and Guattari, 2004) of open source projects and objects that has been emerging since the 1980s which also relates in complex ways to the Lasersaur and enabled it. This assemblage has been transforming in very important ways in the last decade due to the emergence of open source hardware projects such as the Lasersaur. These projects merge open source approaches and the tangible world and therefore are starting to transform both.

The reason for this, I argue in this chapter, is that such open source hardware projects are enabled by and enabling particular relations of people, knowledge and objects. I will trace and identify these relations with a focus on the special 'open objects' (Simondon, 2009) of open source. They are an important key to understand open source practices and they are a novel class of objects with special characteristics. These objects 'structure desire' (Knorr-Cetina, 1997, p. 13) and they enable the processual constitution of globally dispersed groups that produce and share knowledge based on them on the Internet. In the global open source assemblage and in the Lasersaur project particular novel 'technoepistemic cultures', particular ways of unfolding technological objects, are emerging that are of huge significance for the ongoing transformations in the current technoscientific-cultural landscape.

After showing that open source projects depend on open source objects, I introduce the concept technoepistemic cultures which builds upon earlier concepts to analyse the many different ways of knowledge production (e.g. Knorr-Cetina, 1999). Technoepistemic cultures are the different cultures that centre on technological becoming which is entangled with ensembles of technological objects that enable and are enabled by particular knowledge productions. The technological object will then be the carrier of my description of the assemblage that constitutes the Lasersaur project. During all of this chapter, empirical descriptions and theoretical discussions entangle to get a grip on the new realities that are emerging in open source. Therefore, the biography of the Lasersaur project also entails a discussion of assemblage theory. Then, drawing on topology to designate different ways of relating, I describe what I hold to be crucial aspects of the relations in open source hardware assemblages. These, the chapter concludes, are in cultural ways very significant, since they depart in many aspects from the dominant relations between people, knowledge and objects that have been stabilised for decades in industrial societies.

In this chapter I claim that such transformations in imagined and practical ways happen as assemblages, in the coming together of people, objects, information, materials, ideas and so on. It is thus an attempt of this text to merge imagination, practice and technology to where they belong: together. In his book on early cybernetics, Pickering writes, 'how we imagine the world and how we act in it reciprocally inform one another.' (Pickering, 2010, p. 22) In the Lasersaur and other open source hardware projects imaginations and practices are in many ways geared towards the future and the unknown. In this sense the technoepistemic culture of open source hardware that I will describe here is to a certain extent concerned with the future of technology and society, now as it is being enacted in the present. In this lies its cultural and political force. Open source hardware shows that 'another technology is possible' partly already and partly not yet. My text is thus also an attempt at a sociology of the future, yet without seeing the future as a certain entity some years in front of us. Rather, what I will show is that the future, or rather a possible future leaves its traces already in the present. A trace of a difference that has not yet completely happened and is still uncertain (for the idea of traces of possible futures in the present: Bloch, 1995). But how is a project like the Lasersaur possible? And what possibilities do this and similar projects engender?

Open objects and technoepistemic cultures

The Lasersaur and other open source objects are the products of an object-historical change (see Hörl, 2013a for this notion) and trajectory that has been taking place since many decades and is still ongoing: the rise of 'open objects' (Simondon, 2009). Although, open objects are not confined to particular technologies, today, the most impressive example of such objects and their related cultures is the Internet and other computer networks which integrate a mass of diverse open objects[1]. What

1 Of course, there are all kinds of other examples. Electrical instruments come to my mind where it is part of the music culture to change the sounds due to varying constellations of instruments, effects, amplifiers and so on. Or what about extreme sports where people modify their equipment all the time to adapt to local conditions,

is a Wiki[2], if not an open object? Or take your PC and your smartphone: you constantly update your software or install plugins and apps to keep connected to the latest changes of the networks and in turn change your object. And in turn you become at least to some degree a technician, changing and maintaining your artificial life support. These networks can hardly be underestimated for the massive and ongoing changes in societies and cultures during the last decades (e.g. Castells, 2002). According to Hörl we have entered 'the technological condition' due to the cybernetic ecologies of digital open objects which reconfigure agency, meaning, subject and object, indeed our whole 'object-culture' and 'sense-culture' (2013a, 2013b, 2011). I agree with Hörl's diagnosis and argue that the interconnectivity, fluidity and malleability of digital open objects has become a model for open source hardware objects such as the Lasersaur. Indeed, the first open source objects were software programms designed to allow for even greater malleability and availability than their 'closed source' counterparts by Microsoft and the like. But some further clarification of this object-historical change is needed.

Although open source objects are open objects, they are an explicit radicalisation of this class of objects: they are *open source*[3] objects. And it will be a main task of this chapter to qualify the 'source' aspects of these objects and the transformations and challenges such open-sourcing of tangible objects creates. For now, I refer to the open source hardware Association's definition to approach this addition to open objects: 'open source hardware (OSHW) is a term for tangible artifacts – machines, devices, or other physical things – whose design has been released to the public in such a way that anyone can make, modify, distribute, and use those things' (http://www.oshwa.org/definition/, accessed 17.12.2013). The chapter, however, will show in many ways how intricate and complex such 'opening' of a design is. This explicit turn towards the opening of design is what sets the open source culture and its objects apart from other open objects. Open source objects concern much more than their being objects that simply change. I have particular reasons to approach these objects and need certain conceptual tools to do so.

No open source objects – no open source projects

The prime reason lies in the phenomenon open source hardware itself. Extremely condensed the history of the Lasersaur reads like this: Two young artists with a background in open source software wanted to have a laser cutter. Unsure of the actual feasibility, they released their intention to build an open source laser cutter on the Internet. About 200 people were interested and supporters joined a mailing list. Despite very limited resources a first prototype was cutting eight months later.

e.g. mountain biking and skiing. Simondon (2009) even argues that buildings designed in such a way that they can be constantly reconfigured express the technical mentality.

2 The most popular of which is Wikipedia.

3 Although, the history of open source began with 'Free Software', in the late 1990s the notion 'open source software' became dominant, also because it was more compatible with corporate cultures (Kelty, 2008). Open source points at the dual technical structure of software. Underneath the surface that you encounter as a user of software lies the source code which is human readable. This source code, in a way, is the 'design' of the software. All closed source software and thus most of the software around the globe does not make its source code public. This is because knowing the source code enables others to transform the software. Open source hardware or Open Hardware is the main way how the 'open source hardware movement' labels itself.

Three years later about 150 such machines, further developed than the prototype by the community, can be found around the world. Accordingly, the Lasersaur, even as a vision or thought object, was the object around which the community began to form. Objects are an enabler of the open source culture, at the heart of which is the collaborative production, circulation, use, constestation and control of objects and the knowledge about them.

Simondon (Simondon, 2012, ch. 1) argues that standardised objects are not the results of industrialisation, but that industrialisation was the result of the possibility of standardised objects. Such a recursive logic is central to open source as well. As Edgar Morin, a preeminent complexity thinker, puts it, in recursive causality 'the effects and products are necessary to the process that creates them. The product is producer of that which produces it' (Morin, 2008, p. 61). This can be further exemplified with one of the founding myths of Free Software: Richard Stallman, the founder of the Free Software Foundation, was used to share software code within his network of computer programmers and hackers. Yet, with the advent of neoliberalism intellectual property rights tightened around 1980 and corporations increasingly monopolised software code. Thus, something went wrong with the now famous printer at MIT:

> 'I had already experienced being on the receiving end of a nondisclosure agreement, when someone refused to give me and the MIT AI Lab the source code for the control program for our printer. (The lack of certain features in this program made use of the printer extremely frustrating.)' (Stallmann, 2010, p. 9)

While Stallman extensively talks about being helpful to each other and not 'antisocial', the forgotten aspect of this narrative is the objects itself: the printer stopped being an open object of which he was so used to in a research environment. Accordingly, his struggle for Free Software is as much a struggle for open objects as it is for sharing and transparency (two important values in research, a social field that is also very important for the Lasersaur). The birth of Free Software was located in the practical requirements of technologised research environments – where people have to and are used to change technological objects. And these made him explicitly state and formulate the values of Free Software (cf. Stallmann, 2010).

Now, however, the emergence of open source hardware pushes objects into the foreground. In open source software, a network of PCs constitutes the means of production and exchange of code and it allows for communication. Software in such networks is easily reproducible at almost no cost. It circulates lightly and rapidly, which made some argue that an abundance of information and thus an important condition of possibility for open source is bound to immaterial cultural objects that remain within such networks (e.g. Söderberg and Daoud, 2012). But the tangible objects of open source hardware are in important ways – that I will explore here – 'offline' and recalcitrant. They are enabled by more than computer networks and they constitute a need to translate their 'materiality' into the 'immateriality' of information in these networks.

Together, this is very significant: tangible objects have almost entirely been dominated by industrial technoepistemic cultures since the 20th century. Indeed, looking at the billions of industrial objects (from food to technological and cultural objects) that co-constitute social life in contemporary technological societies proves the idea of a 'post-industrial society' (e.g. Bell, 1976) wrong, especially since the production and consumption of objects transcends national boarders. There are only post-industrial tendencies, one of which I will explore. The technoepistemic cultures that have been emerging in open source show the possibility of significant differences to this – differences that this chapter will show. The emergence of this possibility is crucial to understand the hopes, hypes and visions that appeared together with open source hardware and they are also important for the Lasersaur.

The second reason for my choice of perspective is that research about open source has not addressed technical objects in a depth that equals their importance for the phenomenon. This research, furthermore, focused almost entirely on open source software. Although the lines mix, one can discern certain core themes. One important strand focuses on 'hacking' as a value-laden cultural practice and writes about the ethics and aesthetics that sustain it. The 'hacker' is at the core of this perspective (Coleman, 2012; Coleman and Golub, 2008; Himanen, 2001; Jesiek, 2003; important contributions include: Levy, 1984; Moody, 2001). Closely related to this approach is research that focuses on open source as a practical critique of intellectual property regimes and hackers performing such a critique. Open source projects depend on and promote knowledge as a 'commons'. This is contrary to the logic of intellectual property regimes that constitute a mechanism to exclude people from knowledge as a private property and therefore make it 'scarce' through legal means. The famous 'copyleft mechanism', invented by Stallman and legally ensured through open source licences, is symbolically and practically an inversion of copyright by copyright's means (Berry, 2008; Andrè Gorz, 2010; Hardt and Negri, 2009; Söderberg and Daoud, 2012; Stallmann, 2010; e.g. Wark, 2004; Weber, 2004). Then there is a lot of research which investigates the novel forms of organisation of open source projects, the motivations of participants and the internal governance of the projects. Often related to the importance of knowledge as a commons in open source projects it is claimed that open source constitutes a new mode of production based on voluntary action, different to markets and hierarchies (Benkler, 2013, 2006; Feller et al., 2005; key texts include: Ghosh, 1998; Lakhani and von Hippel, 2003; Raymond, 2001). Kelty's (2008) work is integrative of much of this as it argues that Free and open source software is a 'recursive public' that is building the infrastructures for its own existence. Yet, also here, objects remain a vague addon to the argument.

There is actually one study – the exception that proves the rule of the neglect of objects – that can be seen as a precursor to my study. MacKenzie (2005) claims that the circulation and transformation of the coded object Linux is performative of the 'collective agency' of the project. 'As an operational object serving as a platform, Linux quite literally co-ordinates the circulation of specific social actions [...]. At the same time, co-ordinated actions centred on Linux constantly modulate it as an object in self-referential ways' (Mackenzie, 2005, p. 77). Furthermore, circulations of Linux through different technical, industrial and cultural domains enact the object as something that is multiple, yet one – Linux actually is a lot of 'Linuxes' that nonetheless somehow adhere to each other (see for an ontological argument about the multiplicity of objects: Law, 2002).

My third reason for focusing on objects has to do with sociology itself. The social sciences have largely excluded 'objects' from their investigations of social life and instead focused on intersubjectivity and communication (for critiques of this exclusion: Eßbach, 2001; Latour, 2005). Of course, 'objects', 'materiality' and 'things' have started to enter the descriptive and analytic toolkit – not least due to the success of science and technology studies since the 1980s. When talking about globally dispersed and multiple objects such as Linux or the Lasersaur, however, we need a better understanding and conceptualization of what such objects are and how they come to work in certain ways. Only recently, efforts for a dedicated 'object-oriented sociology' came into being (cf. Law, 2002; Lash and Lury, 2007; Marres, 2012)[4]. The approach pursued here joins these efforts and aims for a conceptual level that is appropriate to the entanglements and possibilities open source objects co-constitute. These, however, are based on an object-historical change which goes beyond open source.

The unfolding age of open objects

In 1958 Simondon published his PhD 'On the mode of existence of technical objects' and proposed a theory of technology which was strongly inspired by evolutionary theory, information theory and cybernetics (Simondon, 2012, 2010)[5]. He argued that large cultural changes are entangled with changes in technical objects and in the relations between humans and such objects. The history of modernity has seen at least three grand changes in the constellations of people, knowledge and technical objects. Each of these object-historical changes, however, entangled with huge changes in societies and cultures and established, stabilised and changed technoepistemic cultures, i.e. particular ways how technology is being unfolded.

In pre-industrial technical regimes, craftsmanship was the dominant mode to work on and with technology as tools. Energy and information was provided by the craftsman and the construction of technical objects and their use was rather closely linked, and be it only that artisans knew the users of their tools. This seeming 'unity' is the reason for the romanticised nostalgia for craftsmanship that can still be found in academia (e.g. Sennett, 2008) and in some strands of discourses about the maker movement, where the maker is seen as someone producing technology in self-sufficient ways.

Yet, when machines made the industrial mode of production the dominant regime for technical realities, the constellations changed dramatically according to Simondon. The more complex division of labour split invention, construction, use, maintenance and transformation of technology apart between different individuals and groups, what in Marxist literature is referred to as the split between 'intellectual' and 'manual labour' (Sohn-Rethel, 1978), with 'de-skilling' on both sides as an effect (Braverman, 1974; Sennett, 2008). Such splitting also takes place in spatial dimensions, between factories and research and development units, or recently in extremely far distances due to offshoring (Urry, 2014). 'It is thus a weaker part of the total capacities of the human being that is engaged in the industrial act [… one] encounters the discontinuous through work' (Simondon, 2009, p. 21). In this fragmentation and the possession of the means of production by capitalists, which also means their concentration in factories, Marx (1976) saw sources of 'alienation'. Stiegler

4 In philosophy, the recent movement of 'object-oriented ontology' similarly aims to find key properties of objects and their inter-objectivity (e.g. Morton, 2013).

5 This theory is currently being rediscovered. Simondon had a huge impact on Gilles Deleuze's work which has been becoming more and more prominent in some parts of sociology, STS and anthropology and which is also central to this chapter. Some recent writers on technology draw directly on Simondon, e.g. Hörl (2013b), Stiegler (2010) and Latour (2013). Indeed, this is not surprising, since Simondon's work addresses many contemporary desiderata such as overcoming simple dichotomies such as nature vs. culture and thinking in more relational and processual terms.

(2010) who builds upon Simondon and Marx argues that in contemporary industrial societies besides workers consumers suffer multiple losses of knowledge due to the industrialised circuits of technology and material culture which shape psychological and social everyday life.

Yet, a third shift has been taking place for decades. Simondon hinted at the emergence of 'post-industrial' realities which he linked to the appearance and unfolding of open objects. These objects partly transgress the industrial boundaries between the creation, production and use of technological objects and thus mix some aspects of artisanal and industrial ways of relating to technology. Flusser, in a similar threefold argumentation, saw the coming age of the 'robot' after the age of the tool and the age of the machine. In this age, humans and robots co-function together. 'Thanks to robots, everyone will be linked to everyone else everywhere and all the time by reversible cable, and via these cables (as well as the robots) they will turn to use everything available to be turned into something and thus turned into account.' Accordingly, in the 'factories of the future', Flusser writes, 'manufacturing means the same thing as learning – i.e. acquiring, producing and passing on information' (Flusser, 1999, p. 48, 50).

The diagnosis of the emergence of 'open objects' builds upon Simondon's thinking about technology in general which centres around change and becoming. He 'asserts the primacy of ontogenesis, a primacy of processes of becoming over the states of being through which they pass' (Massumi, 2009, p. 37).

> '[I]nstead of starting from the individuality of the technical object or even from its specifity, which is quite unstable, it is preferable to reverse the problem [… T]he individual technical object is not a datum of the here and now […] but something that has a genesis. The unity of the technical object, its individuality, and its specificity, are consistent and convergent characteristics of its genesis. The genesis of the technical object is part of its being. The technical object is something that does not exist prior to its becoming, but that is present at every stage of that becoming; the technical object is a unit of becoming' (Simondon, 2010, pp. 6–7).

In his 1958 study Simondon already speaks of novel 'open machines' and technical ensembles that share growing margins of indeterminacy. He develops the idea of 'open objects' further in a text written around 1970 and published for the first time in 2006[6]. The text actually is about the emergence of novel technical objects that entangle with a new cultural formation Simondon saw partly developing, the 'technical mentality'.

> '[I]n order for an object to allow for the development of the technical mentality and to be chosen by it, the object itself needs to be of a reticular structure [...] an *open* object that can be completed, improved, maintained in the state of perpetual actuality' (Simondon, 2009, p. 24).

It is the combination of objects into networks and the corresponding culture of changing these technical objects and their relations that Simondon focuses on. Central to open objects thus is the *indeterminacy*[7], the higher rate of change and

6 The text first appeared in French, in 2009 in English (Simondon, 2009) and in 2011 in German (Hörl, 2011). It is a central piece of Simondon's thought.

7 Openness, has been slowly entering the theories of technology against the dominance of construing technology in terms of closure (e.g. Heidegger, the Frankfurt School, Hughes's sociotechnical systems). Wynne speaks of 'unruly

the multi-functionality these objects acquire due to their networks and their relation to the technical mentality. The latter corresponds with people who somehow participate in all ideal typical stages of the technical process: imagination, invention, design, production, use, maintenance and transformation.

> 'If one seeks the sign of the perfection of the technical mentality, one can unite in a single criterion the manifestation of cognitive schemas, affective modalities, and norms of action: that of the *opening*; technical reality lends itself remarkably well to being continued, completed, perfected, extended' (Simondon, 2009, p. 24).

Simondon saw the technical mentality as being a subtle tendency in culture and he was afraid, that it could not further develop. For open objects the 'technical relation' is at least as important as their 'economic'[8] or 'social' relation, the last two being a threat to the becoming of the technical side of the objects.

Besides the recent prominence of open objects, there have been other and ongoing changes that are necessary to understand the emergence of open source and appropriate conceptualisations of it. First, there has been an increasing transgression of boundaries when it comes to knowledge production beyond the boarders of institutionalised science and its disciplines or organised capitalist enterprise. These new messy realities have been labelled 'mode 2 science' (Gibbons et al., 1994) or 'post-normal science' (Funtowicz and Ravetz, 1993), for example. Second, this change has been accompanied by an increasing orientation of research and societies towards 'technoscience' (Forman, 2007; e.g. Haraway, 1997; Ihde and Selinger, 2003; Weber, 2010). It is even argued that we live in an 'age of technoscience' (Nordmann et al., 2011) in which the possibilities and potentials of technological change have become the center of research and much of social life. Technoscience further radicalises the messy and distributed knowledge-centred processes above by bringing the multiplicity of unfolding technologies into the mix. These changes, I want to argue, are entangled with the emergence of indeterminate ensembles of open objects which are an enabler of knowledge productions and have been transgressing the confined settings of institutionalised research and development.

Technoepistemic cultures

As I already indicated, the concept that I propose to analyse the multiple and decentred processes of open source is 'technoepistemic cultures'. The concept builds strongly upon the practice turn in Science and Technology Studies, that investigated how science practically produces knowledge. These studies showed for example, how knowledge is an emergent effect of a 'dance of agency' between humans and material entities (Pickering, 1995), or of experimental systems that centre around surprisingly unfolding 'epistemic things' (Rheinberger, 1997). Within this strand, Knorr-Cetina developed the concept 'epistemic cultures' to capture the plurality of scientific practices that produce knowledge. Epistemic cultures designate the 'sets

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technology' (Wynne, 1988) others considered technologies as 'real-life experiments' (Krohn and Weyer, 1994).

8 Marx already thought of such a dual nature of objects (as commodities): they have use-value and exchange-value. The latter, Marx claimed, was of prime importance in capitalism. And he was proven right: most objects that we face in mundane life are produced for the sake of profit, leading to now well-known effects such as obsolescence. Even the social sciences followed the spirit of capitalism and tended to mainly see objects as commodities (e.g. Appadurai, 1986).

of practices, arrangements and mechanisms bound together [...] which, in a given area of professional expertise, make up how we know what we know' (Knorr-Cetina, 2007a, p. 363, 1999).

Technoepistemic cultures are a specification of epistemic cultures, explicitly turning towards technology. As the sciences have many different epistemic cultures, there are many different technoepistemic cultures: in craftsmanship, in industrial engineering, in the different technosciences, in open source hardware and so on. The term technoepistemic culture has already been used by (Kastenhofer, 2013) to analyse the technoscience synthetic biology, an 'engineering approach to biology'. Whilst she acknowledges that the transformation of objects and the pursuit of novel technological capabilities form the core of this technoscience (see also Nordmann, 2012) she stays with the norms, practices and values that the researchers hold dear. Thus she doesn't go beyond the lifeworld oriented approach of Knorr-Cetina's epistemic cultures. This is insufficient to understand technoepistemic phenomena such as open source practices. When Knorr-Cetina and others studied scientific practices they went to existing laboratories to do ethnographic research. Now, however, open source practices take place across the globe and it is hugely unclear, where exactly and under what conditions. The 'laboratories' of open source practices are themselves in need of explanation. How are such globally distributed knowledge and technology producing processes possible?

They are made possible due to their entanglement with ensembles of open objects. This intuition builds upon Rheinberger (1997) who argued that the dynamics of science are not based upon the dynamics of ideas but upon the transformation and mixing of epistemic things that spread beyond single experimental systems. Other authors have also argued for the significance of the networks or ensembles that objects build. These networks form a 'technoscape' (Appadurai, 1990) in which they interact and move along with each other. 'Inter-objectvitity' is key to many contemporary forms of inter-subjectivity. An analysis of technoepistemic cultures thus needs to capture the 'nexus of lifeworlds (contexts of existence that include material objects)' (Knorr-Cetina, 2007a, p. 364). But it also needs to capture the constitution of these objects and the nexus of objects which enables different lifeworlds to connect in complex, decentred and global ways. Technoepistemic culture points towards questions such as: how are technological objects produced, used, transformed, combined, circulated, known, imagined or contested and how do objects participate in or even enable this? In turn, how has the Lasersaur been unfolding? How did object and project recursively form each other?

Assembly of a project

In this part, I outline the history of the Lasersaur project and am particularly interested in which forms of organisation and organisational support the project engendered. The materials that help me trace the project's biography are varied and multidimensional. Most of my knowledge about the project is based on three qualitative interviews with key persons in the project. In may 2013 I interviewed Addie and Stefan, the Lasersaur's founders, in their studio appartment in Innsbruck. This is also where most of the development work for the Lasersaur took place. Next to us during the two hour interview, neatly integrated into the room, stood the reference machine. Afterwards the two showed the basic functions of the laser cutter to me. In our interview we covered their perspective on the Lasersaur project's history and future, the community and the open source culture more generally. They also pointed towards Till and Mischa, the two other interviewees, since they had special roles in the project.

Till Hergenhahn is the builder of the third Lasersaur, the first one that was built without Addie and Stefan. He leads the educational club 'Aeronauten Werkstatt' in Frankfurt, Germany and is working as a self-employed industrial designer. The interview covered the Aeronauten Werkstatt's mission, his involvement in the Lasersaur and his observations of the open source culture. Mischa Schaub is the director of the 'Institute HyperWerk for Postindustrial Design' at the University of Applied Sciences and Arts Northwestern Switzerland. With a residency in 2012 the institute supported Addie and Stefan and the further improvement of the Lasersaur's design to a great extent. In our interview we talked about HyperWerk, the Lasersaur project and his interpretations of the open source culture. Later on, I will further describe the interviewees and the context they are working in.[9]

The other empirical material for my study may not be underestimated in relation to the interviews. The Lasersaur project's reality *is* to a large extent (in) the Internet and there most of it is publicly available. There is the Kickstarter website that initiated the launch of the project, there are many interviews (text or video) with Addie and Stefan, there's the project's website www.lasersaur.com and the mailing list that one can view. Furthermore, there are many videos of builds of Lasersaurs by different persons or organisations and webpages devoted to the individual building projects. Of course, the Lasersaur project features on Twitter and there are hundreds of pictures on Flickr to complement the documentation of the project. All of these inspired my interpretation of the project. To give a sense of the more-than-textual realities of the Lasersaur I try to mix the empirical material when appropriate to the argument. And I highly recommend my readers to go online and check out the links that I reference in the text. This way one can get a direct phenomenal impression of central elements in the project's assemblage.

There is, however, a third field of empirical enquiry. As the co-founder of FabLab Karlsruhe (www.fablab-karlsruhe.de), an open workshop that makes 3D-printing and other CNC (computer numerically controlled) machines publicly available, I have been in tight contact with open source objects (Schneider, 2015). Furthermore, in autumn 2014 a Lasersaur was built in and for the FabLab and I participated in the building process. As Ingold argued, making is a form of participation in a socio-material world of becoming and therefore a proper method for human and social sciences (2013). Besides the observation of the group, the actual making of the machine was a close and revealing empirical encounter with this object. Whilst the methodological rigourosity is lowering from interviews to Internet and building, all of this is part of my entanglement with the Lasersaur and therefore of the way how I

9 All four interviewees gave their consent that I can use the interviews and make direct reference to their identities. This already points at the atmosphere of the interview situations which in all cases was very positive and based on mutual interest. The interviews took place where the people work and use the Lasersaur and lastet one (Mischa) and two and a half hours (Addie and Stefan, Till). I recorded and transcribed the interviews and analysed them in a qualitative and interpretative manner. With an overview of the interviews I decided to not conduct further interviews since I gathered three different perspectives of people who have been knowing the project from an early stage onwards. And since my focus here is not on different interpretations of the project, but on the conditions of possibility of its realisation, these three interviews provided enough heterogeneous material to complement my other empirical observations.

present it here. I agree with the demands of complex epistemologies necessary for the 21st century that have to integrate the person of the researcher into their research (e.g., Morin, 2008)

Ambient assemblage: the 'maker movement'

The Lasersaur project can be considered an element in a much wider and diffuse assemblage: the 'maker movement'. The term 'maker' in its present connotation was popularised by O'Reilly Media, a company specialised in publications concerning (open source) software, with the launch of their 'Make Magazine' in 2005. The rhetoric strategy behind the magazine's title was to address more people than with the more narrow and partly negatively interpreted term 'hacker'. Yet, far from mere semantics, the magazine has been including all kinds of do-it-yourself projects which do not only feature computers and electronics, the main fields for tinkering of hackers. And the company even started a successful series of 'Maker Faires', large events in the US and beyond about all forms of do-it-yourself, combining commerce, hobby and festival (see the CEO of O'Reilly describing the history of Make Magazine: http://vimeo.com/51841691, accessed 25.06.2014; see also this press release for a further self-description of Make: http://www.oreilly.com/pub/pr/3185, accessed 25.06.2014). In my interpretation Make Magazine successfully participated in the emergence of an assemblage that was happening anyway: the spread of Internet supported DIY practices and the transformation of hacking and open source cultures. Around the same time successful open source hardware projects were launched as well. And in an even wider perspective there has been a growing trend towards 'prosumtion' in many areas, especially due to Internet related practices (Ritzer et al., 2012). The maker movement thus in many ways builds upon cultural framings of the 'web 2.0' that see a new society of decentralised yet networked prosumers being born (Dickel and Schrape, 2014).

In a way, this is simply a D.I.Y. magazine. In another way, it was launched at a time when D.I.Y. increasingly became D.I.T. (do-it-together) due to the Internet. D.I.Y. became something that was up to date again.

By now, the maker movement is an umbrella term for all kinds of practices and ideas ranging from dedicated open source practices to do-it-yourself as it has been taking place for decades, which are now tied together as a 'movement'. Some exaggerating 'visioneers' (McCray, 2012) already herald the maker movement as a sign for a next industrial revolution (e.g. Anderson, 2012). Yet, 'maker' doesn't only succeed in its prominence due to US companies and intellectuals. 'Maker' also resonates with older discourses of the creative and productive individual, powerfully inscribed into modernity, often as a romanticised antidote to industrial and bureaucratic realities. And more mundanely, it resonates with people simply enjoying to make stuff for themselves or together (e.g. Gauntlett, 2013).

Visioneering the Lasersaur I

A good start to follow the Lasersaur's line of becoming is in New York around 2006, decades after laser cutting was first applied in industrial settings. Addie and Stefan, the future founders of the Lasersaur, were studying in the 'Interactive Telecommunications Program' of New York University where students 'explore the imaginative use of communications technologies'[10]. This is not only a programme with lecturers that promote emancipatory ideals in relation to the Internet such as Clay Shirky (2010, e.g. 2008) but also a place where research and development with new media (i.e. technological objects) takes place. They graduated with an open source hardware multi-touch system (roughly similar to touch screens of smartphones) and were already experienced with open source software. They were active in and supported by the thriving nexus of art, technology and open source culture in New York, e.g. at 'Eyebeam'[11]. And they were working with laser cutters for their own creative projects. In 2006 they started their studio 'Nortd Labs' as 'a collaboration based studio of creative thought that engages science, art and design [and that believes that] people should collaborate globally and build locally' (labs.nortd.com/about, accessed 01.04.2014). When they moved to Innsbruck as self-employed artists/designers/technologists in 2009, however, they neither had access to laser cutters and other equipment nor the presence of a strong hacking, art and science community anymore.

Without this equipment, Addie and Stefan wanted a laser cutter as a tool and quickly accepted that industrial machines with prices of tens of thousands of Euros were out of financial reach for them. Inspired by their former work and confident in their technical abilities the two began thinking about building a laser cutter themselves. Around the same time, friends of them launched Kickstarter.com, one of the first and now very prominent 'crowdfunding' websites. Such crowdfunding started mainly with artistic projects that could be supported financially by anyone before their realisation. The goal is to let the 'crowd' fund certain projects with small to medium amounts of money for an individual (starting from around 1 Dollar) that add up to larger sums. Curious about crowdfunding, yet unsure what would happen, Ad-

10 'ITP is a two-year graduate program located in the Tisch School of the Arts whose mission is to explore the imaginative use of communications technologies — how they might augment, improve, and bring delight and art into people's lives. Perhaps the best way to describe us is as a Center for the Recently Possible'. (http://itp.nyu.edu/itp/, accessed February 2013)

11 'Founded in 1997, Eyebeam was conceived as a non-profit art and technology center dedicated to exposing broad and diverse audiences to new technologies and media arts, while simultaneously establishing and demonstrating new media as a significant genre of cultural production'. (http://www.eyebeam.org/about, accessed February 2013)

die and Stefan put their idea to build an open source laser cutter on Kickstarter in May 2010 (https://www.kickstarter.com/projects/nortd/lasersaur-open-source-laser-cutter-0, accessed 08.02.2014). In July 2010, 260 people signed up for support for the project and pledged 20.000 Dollars to it. In our interview, Addie said that this was

> 'exciting but it was also like this oh fuck stage because it meant that we actually had to do it! So then it was like it became real I feel like at that point when we got all these backers and people got excited about it and we saw that there were other people wanting to do it' (Addie and Stefan, p. 4).

The project became 'real' as a social project with mutual expectations and a shared vision. This is a prime example how 'postsocial' intersubjectivity with its desires for unfolding technological objects works, objects that 'structure desire' of subjects and collectives (cf. Knorr-Cetina, 1997). Yet, this also tells that sticking with the lifeworld of Addie and Stefan wouldn't go far enough to understand the Lasersaur.

Addie and Stefan play a crucial role in the design *of* and *with* the Lasersaur project. They did not only design a technical machine, as classical industrial designers or engineers would do, they co-designed a social development and design project centered around the technological object Lasersaur. As Stefan put it: 'I guess there are two things we did. It's, you know, we developed the technical thing, the reference design, and the other thing is sort of, you know, develop the community' (Addie and Stefan, transcript, p. 19). Such multidimensional design and/or organisation of a whole socio-techno-logical process is central in the new relations between people, knowledge and objects that the open source culture engenders. Kickstarter shows the need for an analysis that is capable of dealing with heterogeneous relations (across time and space), emergent effects and processes. As I already indicated, the conceptual tool I choose for this is assemblage (Deleuze and Guattari, 2004). Seen with this tool the 'oh fuck' is actually one of the first emergent effects of the assemblage that has started to form the Lasersaur project. As Deleuze and Guattari would say, it is not the feeling of Addie, but a 'collective enunciation' of the assemblage. How does assemblage theory lead to such insights?

Assemblage in theory

Similar to other concepts such as network, system or Actor-Network-Theory assemblage offers a way to describe and analyse part-whole relationships. Assemblage theory was first elaborated by Gilles Deleuze and became a central aspect of his collaborative work with Félix Guattari (Deleuze and Guattari, 2004). It is a concept with strong ontological claims about how the world as process is formed in and of relations between heterogeneous elements and the emergent effects of such relations. To me, it is a key concept to work towards a 'general ecology', to foster epistemic and ontological thinking in relational and processual ways appropriate to contemporary technological environments (c.f. Hörl, 2013a). The original French word 'agencement', translated into English as assemblage, has a dual meaning of ordering or assembling and of something being an arrangement (Deleuze and Parnet, 1987, pp. vii–viii). This active and passive sense is also part of the analyses of Deleuze:

> '[An assemblage] is a multiplicity which is made up of many heterogen-

> eous terms and which establishes liaisons, relations between them, across ages, sexes and reigns – different natures. Thus, the assemblage's only unity is that of co-functioning: it is a symbiosis, a “sympathy”. It is never filiations which are important, but alliances, alloys; these are not successions, lines of descent, but contagions, epidemics, the wind' (Deleuze and Parnet, 1987, p. 69).

Deleuze and Guattari locate such co-functionings in wasps that pollinate orchids, in books that are written and read, in metals that react with each other or in big societal formations as feudalism or socialism – each assemblage changes itself and its elements over time, also in co-functioning with other assemblages. Yet, assemblages form recognisable entities and can be rather stable. They are not seamless wholes, however, but rather open complexes and one has to find their processes and times of opening and closure empirically (Harman, 2013).

Recently, the philosopher Manuel DeLanda has substantially added to assemblage theory as a theory for social analysis (2006). DeLanda argues that in the dominant organismic metaphor for wholes (e.g. as in 'society as an organism') parts and whole mutually determine each other through '*relations of interiority*: [where] the component parts are constituted by the very relations they have to other parts in the whole' (2006, p. 9). Contrary to this, assemblages have 'relations of exteriority' which imply 'that a component part of an assemblage may be detached from it and plugged into a different assemblage in which its interactions are different' (2006, p. 10). Deleuze describes this above with 'co-functioning', 'sympathy' or 'alliance'. Accordingly, assemblage theory shifts the focus of attention to the historically contingent processes that give form to and change groupings and the elements that group together.

Assemblages can be full of dynamics, surprising movements and latent processes. They can be transformed due to their own or other's 'lines of becoming':

> 'A line of becoming is not defined by points that it connects, or by points that compose it; on the contrary, it passes *between* points, it comes up through the middle, it runs perpendicular to the points first perceived, transversally to the localizable relation to distant or contiguous points. A point is always a point of origin. But a line of becoming has neither beginning nor end, departure nor arrival, origin nor destination [...] A line of becoming has only a middle. [...] A becoming is neither one nor two, nor the relation of the two; it is the in-between (Deleuze & Guattari, 2004, p. 323).

To conceptualize these processes of assembling and change, DeLanda (2006, pp. 8–19) uses three axes of analysis. First, one has to clarify what the component parts of an assemblage are and acknowledge that they can have *material* or *expressive* roles or a mixture of the two in the assemblage, i.e. there are relations that produce certain effects and others that convey information. Second, there are processes of *territorialization* or *deterritorialization*, which 'either stabilize the identity of an assemblage, by increasing its degree of internal homogeneity or the degree of sharpness of its boundaries, or destabilize it' (DeLanda, 2006, p. 12). Third, there is *coding* and *decoding* also affecting the identity of an assemblage. In social assemblages this is mainly based on discourse and norms, but there can be other forms of coding as well, for example economic coding (Deleuze and Guattari, 2004 chap. 1). DeLanda gives the example that an organization can be highly coded with strict bureaucratic rules. Another organization may be based on informal rules and more open to novelty and change and thus be rather decoded.

Crucial for DeLanda is that all these processes interact with the capacities and properties of the elements of an assemblage. The anthropologist Tim Ingold (Ingold, 2013, 2011) has convincingly argued that all entities in a world that is alive, e.g. materials, organisms or artefacts move along a trajectory with a history, present and possible futures. During this they entangle and 'co-respond' with elements in movement, which changes their paths. Through being in an assemblage, elements acquire certain properties but these need not necessarily encompass all their capacities. In a different assemblage, other capacities of an element may be activated. Therefore, each assemblage creates 'spaces of possibility' which enable and constrain what the assemblage as a whole or certain elements can 'do' (DeLanda, 2011). Each element, however, is not a distinct entity rather it is itself an assemblage. An assemblage is formed of assemblages, none of which is reducible to another.

Accordingly, assemblage thinking lends itself well to consider technical objects in their specific trajectories as part of larger ensembles:

> 'But the principle behind all technology is to demonstrate that a technical element remains abstract, entirely undetermined, as long as one does not relate it to an *assemblage* it presupposes. It is the machine that is primary in relation to the technical element: not the technical machine, itself a collection of elements, but the social or collective machine, the machinic assemblage that determines what is a technical element at a given moment, what is its usage, extension, comprehension, etc. [...] Thus one cannot speak of weapons or tools before defining the constituent assemblages they presuppose and enter into.' (Deleuze and Guattari, 2004, p. 439)

Serres gives a nice example of similar relational object-thought in his theory of the 'quasi-object' where the ball is the enabler of the football game and thus of intersubjectivity. 'The ball isn't there for the body; the exact contrary is true: the body is the object of the ball; the subject moves around this sun. Skill with the ball is recognized in the player who follows the ball and serves it instead of making it follow him [sic!] and using it' (Serres, 1982, p. 226). Ball, players and onlookers compose the assemblage football game. Objects, however, are not confined to material things or stable entities. And the functions they have and the effects they co-produce are emergent in the assemblage. With the ontology of assemblage, it becomes possible to think and describe objects as objects, yet in process; entities, yet part of networks; 'objective' things, yet entangled with sociality and subjectivity. Actually, they become much more than is commonly thought to be an 'object'. So how is the Lasersaur enabled by the forming of an assemblage?

Visioneering the Lasersaur II

The Kickstarter experiment is quite telling about the qualities of the Lasersaur assemblage and therefore I will analyse it in more detail with the axes of analysis for assemblages laid out. What were the 'material' roles of certain elements of the Lasersaur assemblage in its early stage when it is co-functioning with the assemblage of Kickstarter? Of course, there were Addie and Stefan who produced texts, images and videos that they uploaded to the Internet and its network of PCs that enables their circulation. And there was the structure of Kickstarter that links the circulation of money to the circulation of the vision of the project on Kickstarter. Thus, closely linked are the 'expressive' roles of the elements. Addie and Stefan and their vision appeared in the condensed form on Kickstarter: 'We believe we are able to design a laser cutter that can be built for under 5k (a 100W version) [...]. It would be completely open source and repeatable.' Besides their plan to design the machine, the 'rewards' for backers already give a hint at how Addie and Stefan imagined the project. For example, 24 people pledged 512 $ each to get an 'Alpha Kit' that promised: 'Get Alpha Access PLUS a super limited edition kit with all the parts to make a laser cutter from motors, frame, and laser!' (https://www.kickstarter.com/projects/nortd/lasersaur-open-source-laser-cutter-0, accessed 14.02.2014). Although it was still rather vague, an initial 'coding' of the assemblage took place. The discoursive references to 'open source', 'making' and to making a design 'accessible' and 'repeatable' at low cost designated the Lasersaur as a project that aims to empower people by giving them access to tools – a powerful trope in the open source culture.

Addie and Stefan link this empowerment in an analogy to the rise of Personal Computers on Kickstarter.

> 'Remember when people couldn't make their own videos, CDs or print out photos? Me neither (at least we try to forget). In many areas of media, the last century was quite the read-only culture where a few gatekeepers would sit on the means to produce everything. Not the best situation for creativity or for people with lots of cool ideas but no cash. When you look at robotics and fabrication this is still the case' (https://www.kickstarter.com/projects/nortd/lasersaur-open-source-laser-cutter-0, accessed 14.02.2014).

Addie and Stefan thus integrate the project discoursively into the wider vision of 'personal fabrication' or 'digital fabrication'. Similar to the PC, digital fabrication shall democratise production and unleash a new age of creativity. This is the key argument in the vision of digital fabrication made popular especially by Neil Gershenfeld, the founder of the FabLab movement (Gershenfeld, 2005).

Ambient assemblage: CNC and CAD – from industry to living room

Digital fabrication is partly entangled with two other assemblages that have been shaping the manufacture of objects for some decades now. The first is automation technology, so called computer numerically controlled (CNC) machines that have been entering and re-organising factories from the middle of the 20th century onwards. These machines, as David Noble showed, originated in military research and were not simply a way to make machines more efficient, these technologies have also been used by management to break organised labour and deskill workers (Noble, 1984; see also Söderberg, 2014). The computer control that quickly and precisely reshapes what the machine does is central to digital manufacturing as well. Closely related to CNC is the emergence of computer aided design (CAD) which started as a way to support technical drawings and turned into the complex composition of three dimensional models of constructions. CAD nowadays is central to many technology developing professions.

Yet, these two assemblages go beyond industry and its technologies. Many technosciences such as nano technology, which aims to shape matter 'atom by atom' or synthetic biology which wants to engineer organisms from bits of DNA are build upon the imagined and partly practical possibilities to design matter with the help of computers, models and machines. Eric Drexler's 'nano assembler' is a visionary predecessor to the vision of digital manufacturing, a machine that produces any kind of tangible object from atoms – similarly the 'replicator' in Star Trek produces any object one wishes. There is a coming together and mixture of matter and controlled digital information thanks to simulations, machines and cultures (cf. Milburn, 2010). Certain technosciences share a key ingredient that reappears in the open source digital manufacturing assemblage: the potentials of such computer design are at least as important as the already realised practical possibilities of these technologies. Now, with PCs being a part of homes and machines such as 3D-printers and laser cutters becoming available to people outside industry and research, CNC and CAD also partly change their shapes.

Vilém Flusser argued that information technologies radically transform the way we give form to things, they vastly reshape how we relate to and imagine the material world, which has become a project rather than a given: 'the "burning issue" is therefore the fact that in the past [...] it was a matter of forming the material to hand to make it appear, but now what we have is a flood of forms pouring out of our theoretical perspective and our technical equipment, and this flood we fill with material so as to "materialize" forms. [... N]ow it is a question of making a world appear that is largely encoded in figures, a world of forms that are multiplying uncontrollably. In the past, it was a matter of formalizing a world taken for granted, but now it is a matter of realizing the forms designed to produce alternative worlds.' (Flusser, 1999, p. 28) These alternative worlds are produced under the condition of networked digital technologies and their entangled cultures; they are products of technosocial collectives that change the way how form to technology is given and that are experimenting with fully realizing the forms that come into existence digitally. In the promise of digitally formed objects lies the promise to reformed socialities.

Yet, making the project public via Kickstarter and fund it that way had a particular 'coding' effect which is not simply discoursive but rather economic or monetary. Kickstarter enabled the collection of money as a form of support in economic and symbolic terms. On the surface, there was money adding up to fund the project on Kickstarter. Yet, this adding up of money as it is being visualised by the website also showed how a group of supporters was growing, how an initial project community was emerging. People literally made an 'investment' in the object which still was the vision of something to emerge in the future. Addie and Stefan told me, however, that the money accumulated on Kickstarter was important, but that the most important outcome was the publicity for the project and the group that formed.

Kickstarter 'territorialized' the project by enabling an initial form of intersubjectivity based on the data streams, texts, images and communications that Kickstarter produced and collected at a central place. Kickstarter embodies the idea that the diffused, decentralized 'crowd' of the Internet can gather and create powerful effects based on small individual contributions that add up. An idea that is also embodied in mailinglists or wikis, the first of which is very important for the Lasersaur. This principle is also a driver of the open source culture. Kickstarter enabled the group to communicate and interact with comments or messages by Addie and

Stefan to every backer. And these exchanges are even stored and the early stage of the project is being carried into the future by Kickstarter's storage. Even after the campaign was over, many people entred the project via Kickstarter. Kickstarter was/is a powerful 'socialiser' of the project. It's worth mentioning that I discovered the Lasersaur via Kickstarter as well. And so did Till and Mischa, my two other interviewees and participants in the project.

In a way, decentralisation was enabled by a center. Such partly paradoxical interplays will be important for the project's dynamics following its launch on Kickstarter: There are questions of openness and closedness, transparency and intransparency, accessibility and restriction that can't simply be seen one or the other way just because the Lasersaur is an open source project. Open source has to be produced in the messiness of the world. Kickstarter was also an engine for the 'deterrioritorialization' of the project, spreading the vision beyond Addie and Stefan and also taking control partly out of their hands. Giving potentially everyone the possibility to pledge money to the project and thus to have a stake in it could have been a strong destabiliser of the project's identity.

A central aspect of this phase in the Lasersaur's biography is 'visioneering' (McCray, 2012), the design of a vision and efforts to realise it. It wouldn't be adequate to simply consider Addie and Stefan as visioneers. Rather, visioneering takes place in an assemblage. The desire to have such a machine grows in an education environment based on the belief in the world-changing nature of new media, it is spread online and energised through feedback loops. But there is a much larger cultural landscape beyond what Kickstarter is able to visualise and to do. Desire is fostered by ethical codes (open source) and machines (e.g., PCs) that have begun to show their potential to change. It is the very concrete actualisation of a social imaginary that increasingly places technology at the centre of its hopes (Knorr-Cetina, 2007b; Nordmann et al., 2011). The visioneering succeeded when the assemblage reached the critical point to start realising its envisioned line. This is what I meant above with the 'oh fuck' being a collective enunciation of the assemblage.

Prototyping the Lasersaur

With the successful Kickstarter campaign, the 'alpha stage' of the project continued. Addie and Stefan continued developing the prototype – they had already done some initial research before the campaign. As they pointed out in our interview, Kickstarter drew some very knowledgeable people into the project who greatly supported the early development process with their knowledge about lasers and building machines. Furthermore, other open source projects, e.g. on 3D-printers and other CNC machines provided much inspiration, suggestions and materials. Yet, the first months of the project it was mainly Addie and Stefan and loads of parts that they bought to experiment with and improve their initial design. They had a crucial function as collectors and assemblers of knowledge, as they worked alone on the machine but could draw upon information that they got on the Internet or by others. Such assembling of knowledge by individuals is very significant and was also important in building the machine in the FabLab (see below).

In November 2010 Addie and Stefan created an emailinglist and invited their supporters on it. Due to their participation in other open source projects Addie and Stefan knew a lot about the difficulties of online cooperation and interaction. There can be unfriendly emails, unstructured communication, negative or even overtly destructive attitudes. To help set a productive attitude amongst the community members Addie and Stefan invited experienced friends onto the email list. As Stefan describes the problem: 'So it is really a lot of effort how you shape and make sure people are really nice to each other and like, you know, set the right tone' (Addie and Stefan, p. 19). Another design decision influenced the mailinglist's atmosphere. Since the project's beginning, one can only actively participate in the online discussion as an initial backer on Kickstarter or if one pays a small fee of currently 32$. Reading the list, however, is free. This small amount of money is enough to only have interested people make the move into the email list – and it financially supports the work of Addie and Stefan a little. Since its launch, the mailinglist has been the main element in the project to facilitate communication. It is a place where new people introduce themselves and briefly a sense of 'community' is being acknowledged, such as when a member of FabLab Karlsruhe introduced himself and the upcoming building of a Lasersaur. One of the most active members of the list replied: 'Hi Wolfgang, Welcome to the Lasersaur community. Answering questions (and asking a few of our own) is what we do best here - so don't hesitate to ask for help.' (https://groups.google.com/forum/#!searchin/lasersaur/wolfgang/lasersaur/NZb3_FLdStA/oQDMfM8mZp0J, accessed 10.11.2014). The questions that are being asked and answered, however, are mostly technical questions. The community is object-centred and aims to learn about and unfold the machine. The object is the medium that enables and engenders inter-subjective communication and communion.

Eight months after the successful Kickstarter Addie and Stefan had the first prototype cutting with a 40W laser tube. A central step in the project, since from now on the prototype could be shared with the community. As Addie commented on this: 'The first time Stefan turned it on and ran it, remember this, like that cutting video [S: jaja], it actually worked and it was like oh wow this is crazy, like it actually kind of cuts! It didn't blow up or anything, so that was exciting' (Addie and Stefan, p. 4). The money they got through Kickstarter, however, didn't last that long to keep the research and development process going on. To further improve their design, Addie and Stefan asked universities for support. Culture Lab at Newcastle University, UK, an institute for digital interaction and digital media, answered and supported Addie and Stefan in building the second ever Lasersaur together with students. Their residency there in May 2011 further improved the cutter and was the first test for the repeatability of the building process.

The second test for the repeatability took place, when Till Hergenhahn at Aeronauten Werkstatt startet building their Lasersaur in June 2011. The club has been conducting educational workshops about science and nature, with children since several years. With their experimental and hands on approach to scientific issues they want to give children an insight into science, sustainability and craft that traditional schools usually don't offer. Yet, their workshops were getting more complex. In need for a (cheap) laser cutter to precisely produce materials out of paper, plastic and thin wood for workshops with kids, Till started searching the Internet for possibilities and through Kickstarter got introduced to the Lasersaur project. Till became a backer of the project after it was already successfully launched. In spring 2011 he received his 'Alpha Kit' with electronics and custom parts made by Addie and Stefan to build his Lasersaur along with standard industrial parts he still had to buy. A charity gave enough money (about 5000 €) to fund the acquisition of the parts. And together with a class of pupils and their physics teacher Till built the third ever Lasersaur within two weeks. Since then, the Lasersaur at Aeronauten

Werkstatt has been cutting materials for workshops and it has become part of workshops as well. As Addie pointed out, Till was not only inspiration as the first builder but also because he took the Lasersaur into a novel context of use. A creative movement that is normatively inscribed into the project: spread laser cutters into areas where they haven't been in this way before.

Although more Lasersaurs were started being build in summer 2011, and the knowledge base was building up, the project faced difficulties. In an email to the community, a year after the successful Kickstarter, Stefan reports:

> 'We have spent the last year working pretty much full time on the Lasersaur while living and developing on just over 10k USD. It's been sort of insane. It's been a lot of late nights, long weekends and ramen. There is more to do. We love this project and our hearts are very much in the open source movement, yet there are some realities which we face – like paying rent and buying RD materials which is becoming harder and harder' (https://groups.google.com/forum/#!searchin/lasersaur/future$20of$20lasersaur/lasersaur/PsJIGufwt0Y/SvECGnF5g5EJ, accessed 12.02.2014).

The email goes on with ideas about how to acquire more money for the sustained work on the project by Addie and Stefan – none of which was realised. Around the same time, however, Mischa Schaub, director of HyperWerk, introduced himself to the mailinglist and soon became an important supporter of the project.

HyperWerk came into being with the new media enthusiasm in the 1990s. It conceives of itself as an interdisciplinary institute for design that provides an environment for research and education beyond the confines of the dominant cultures in universities. Accordingly, it has been aiming at experimental approaches to learning and design. Open source projects such as Arduino micro-controllers and RepRap 3D-printers (both started around 5 years before the Lasersaur) have been used in their work. At HyperWerk students and lecturers were already working with a Chinese industrial laser cutter. Yet, Mischa Schaub wanted to have Addie and Stefan share their experiences and expertise with the students since he saw great potentials in this form of design work especially for students and early career designers. He invited them to become fellows at HyperWerk and build a Lasersaur together with students. In November 2011 Addie and Stefan together with their small child moved into a flat provided by the institute and stayed over for several weeks to build another Lasersaur. In 2012 they became fellows at HyperWerk and worked on a 200W version of the laser cutter to push the technical boundaries of the design. Unfortunately, this did not work. Yet, the work together with HyperWerk greatly improved the design of the machine and supported Addie and Stefan in making a living.

Besides the work of Addie and Stefan the community kept on growing. More people joined the mailinglist and the discussion about the laser cutter. Whereas at first rather few people contributed to the list the numbers increased over the years. In May 2013, when I interviewed them, Addie and Stefan said that about 1000 people were on the mailing list and about 20-30 very actively contributing to the further refinement of the Lasersaur. There has, however, also been a qualitative shift in the community. At the beginning the 'early adopters' were rather skilled in building machines. But with the documentation of the building process getting better and the project becoming more popular people who were less technologically skilled started to build a Lasersaur. This increased the amount of questions concerning the building process and the effort that had to be made to moderate the mailinglist. Addie and Stefan told me, how this has become rather energy consuming and partly annoying. And Till and Mischa pointed out how greatly they appreciated the patience and endurance especially of Stefan concerning the replys to the same questions over and over again, yet by new people.

Although the project has already been running much longer than Addie and Stefan had initially planned, in spring 2013, they were satisfied that members of the community were increasingly modifying the design and taking over work for the project. Here, it's central that the laser cutter itself as an 'unfolding structure' (Knorr-Cetina, 1997) has its own pull in the project. People were demanding more precision, more speed, more strength of the machine and some were offering parts of solutions. As Till remarked, probably the project will never be finished – which he thought to be quite interesting from the perspective of an industrial designer, since in industrial design designs are finished at some point and then produced. Addie and Stefan when talking about challenges considered this unfinishedness as well:

> S: 'there are a lot of technical challenges. It's like from making it work to making it work really well is you know all the work. We got it working in eight months after the Kickstarter it was working and then making it work so, you know, students at the university can just beat the crap out of it and it runs smoothly, it's so hard. That's like where all the work is.
>
> A: Even the commercial systems fail there. So then it's like finding ways to- [S: it's not just us] Yeah, it's not just us. I think that's the hardest part. […]
>
> S: Sort of the last ten percent are like two hundred percent of the work. It's completely out of proportion and you kind of keep going because the community motivates you […] What kept you going in the beginning also makes you look at really complicated things that you never set out to solve' (Addie and Stefan, transcript, p. 24).

One of the surprises the technological object engendered was, how much it offered for its continuation. At the beginning, Addie and Stefan thought they could release the project open source after six months. When they finally declared the project 'mature', it was the end of 2014. Yet, besides enormous amounts of work, the Lasersaur has also helped them to successful careers. Addie is a sought after artist and core member of the open source hardware Association and Stefan has been working at the university on a position that was created especially for him, one of the leading experts in open source hardware.

A crucial feature of this second phase in the Lasersaur project is 'prototyping', which can be considered an increasingly important cultural form in the flux of contemporary technosocial arrangements (cf. Corsín Jiménez, 2014). This not only involves setting up a running machine but also organising a community based on Internet technologies. Both, in a way, unfold, yet remain unfinished in a prototypical stage with no clear form being simply imposable on either. It is rather the recalcitrance of object and community, both open to change, that moves the assemblage in unexpected ways. Although, there is stability over time, it is provisional, established as a further feature of a prototype, yet never the last one. Like visioneering, with which it is still entangled, prototyping takes place in an assemblage. The Lasersaur has never been an assemblage on its own. Rather, it draws on the effects of many other (non-)open source assemblages be it in technological, cultural, social or subjective ways. Part of a much larger global assemblage of open source culture, that has been emerging since the 1980s, Lasersaur nowadays occupies a place within the core of the hardware strand of this assemblage. It is a project of 'digital fabrication' which is strongly supported by 3D-printing communities, visions and the FabLab movement. Addie and Stefan have personal ties to other successful open source designers and work with the open source hardware Association. These multiple and complex relations are at the heart of the Lasersaur's success. In the following I will address these and show how 'knowledge' moves in between and within these assemblages to produce the Lasersaur.

Topologies of open source hardware

Central to open source practices is the mobility of knowledge that enables the often distant collaborations in the projects between people spread across the globe. For people to collaborate in designing and using technological objects such as the Lasersaur, knowledge has to pass and circulate between and amongst them, be it 'online' or in co-present exchanges with people or objects. The relationships of space and knowledge are absolutely central to open source practices. More explicitly than before I will consider the Lasersaur through the lens of the entangled mobilities of people, objects, information, data, images and texts (see for the “mobilities paradigm” Sheller and Urry, 2006; Urry, 2007) which together produce open source assemblages and the relations within them.

In open source assemblages knowledge is spatially distributed and configured and the technoepistemic culture of open source is product of and producer of the resulting dynamics of knowledge. Put another way, knowledge is a relational effect of the complex and multiple relations that co-constitute open source assemblages. In the following I will complexify the analysis of the Lasersaur assemblage by showing how it simultaneously engenders and enacts different versions of its technological object. I will do this based on the topological approach to objects developed by John Law and others (Law and Mol, 2001; Law and Singleton, 2005; Mol and Law, 1994). This approach builds upon ANT in that it sees objects and knowledge as relational effects, think of Latour's immutable mobiles that transport scientific facts beyond laboratories. But Law and others showed how there are more versions of objects than the ones stabilised by actor-networks. They drew on topological reasoning and showed how objects are the enactment of different relational spaces that go beyond Euclidean three dimensional space. Topology, with its focus on relations, multiple spatialities and especially order and continuity has strongly influenced social and cultural thought – not least Deleuze – and provides a promising perspective onto the complex dynamic relations in contemporary technological societies (see also Hörl, 2013a; Lury et al., 2012). In topology

> 'invariance and intrinsic change (understood as deformation) are not incompatible; rather they are rigorously inter-related. Put another way, topology is the setting up of spaces of different kinds of order and continuity in such a way as to enable deformation or change […] the continuity of transformation' (Lury et al., 2012, p. 8).

To make this more concrete: In the following I will analyse which aspect of the technological object Lasersaur, i.e. which form of relation, is 'taking place' when and how. Law and Mol (2001) introduce four different enactments of objects that create their corresponding relational spatialities (topologies). There are objects in a *region,* network objects in *network space,* fluid objects in *fluid space* and fire objects in *fire space.* These different spatial enactments of objects, in some way or another, interfere with each other, yet they are distinct – they turn 'one object' into many objects.

Finding Lasersaurs

First, I will consider the regions of Lasersaur and answer a seemingly simple question. Where in Euclidean three dimensional space are Lasersaurs? In April 2011 a member of the Lasersaur community set up a Google map where builders of the Lasersaur could simply add their location (https://maps.google.com/maps/ms?ie=UTF8&hl=de&oe=UTF8&msa=0&msid=212793647571970047289.0004a1eb83351b9926511, accessed 07.04.2013). By April 2014 58 locations were put onto the map – far less than there are Lasersaurs since not everyone put themselves onto the map. But the map shows that visibility is one important aspect to building a community. And it furthermore gives a hint as to where the concentrations of Lasersaurs are: Europe and Northern America. One can find some other locations on the map. But the picture is not surprising. The regions of the 'West' have the richest and most highly technological societies and thus provide the material and cultural basis for such an expensive open source project. Addie and Stefan told me how there are people in the community from all over the world. Yet, as they and Till pointed out, English, the working language of the project, also creates barriers, as would any language. There is, however, already translation taking place, such as by a Russian FabLab whose members translated the Lasersaur documentation into Russian (http://wiki.lasersaur.ru, accessed 15.04.2014).

Besides the geographical space of Lasersaur the question of social space remains. Who are the people that joined in the project? This question is hard to answer. Addie, Stefan, Till and Mischa were all wondering about it. Of course, there are many people that introduced themselves and their motivations to build the machine. But there are many others that didn't. Addie and Stefan estimated that about 150 Lasersaurs were cutting around the globe in spring 2013 but probably there were more. Addie said, how she once heard of a Lasersaur built by someone who never wrote something on the mailinglist. There is enough material and instructions online to do this. In assemblages there remain elements and processes that are not 'seen' by particular other elements. But the question can be answered at least in some detail. Besides hobbyists and individuals some small companies, e.g. design studios, built a Lasersaur to work with. Some schools built Lasersaurs to educate their pupils and to have the machine in their workshops. Similarly, quite a few universities had building projects. There are even examples, where professors who were critical at the beginning, especially concerning security issues, towards the plan of Addie and Stefan built a Lasersaur with their students after they saw that it is doable. This strong link to educational and research institutions – remember ITP, Culture Lab, HyperWerk – is shared by two of the largest open source hardware projects so far. Arduino microcontrollers (www.arduino.cc) started based on a master's thesis at an Italian design school. The RepRap 3D-printing project (www.reprap.org) – which is the foundation of the recent 3D-printing hype in the media – started at the school of engineering at the university of Bath, UK. Going further back in time, even Linux has its early roots in the context of research and universities.

A new form of education, research and technology oriented organisation has also been important: FabLabs and maker spaces have been building their Lasersaurs and working with them, as FabLab Karlsruhe has been doing since autumn 2014. FabLabs centre around 'digital fabrication', i.e. 3D-printing and so on, so a laser cutter is a neat fit. I just want to give a recent example. In January 2014 the maker space 'Toronto Tool Library' held a public building workshop and has since been cutting with the machine. And of course they have been proudly advertising their new machine on the Internet with one of the often seen cutting videos (http://vimeo.com/90188303, accessed 10.03.2014). These videos give proof that building and using an open source laser cutter actually works. In this they parallel technoscientific demonstrations of the control of a new technological capability (Nordmann, 2012). In 2011 Addie and Stefan also send such proof of the first cut around the world with a video of the first cutting prototype (http://vimeo.com/20809614, accessed 10.03.2014).

Apparent is the striking absence of industry or larger companies in the project. Although this might change in the future, so far the Lasersaur has mainly been circulating in organisations and fields of practice that are more keen to experiment with open source technologies than to produce things for selling them. The Lasersaur has a closer fit with technoscientific cultures than it does with commercial cultures. Clearly, the Lasersaur project is not antagonistic to markets. Although, the design has been under a restrictive Creative Commons licence that permitted only non-commercial use of the design, Addie and Stefan offered potential entrepreneurs to get in touch with them. In late 2013, in a further move towards fully releasing the project to the public, the two changed the licensing to allow commercial use of the design but restricted use of the Lasersaur name and logo, i.e. the 'branding' of the project, to only non-commercial use. So far, however, there is no effort going on to build a business around the Lasersaur or with its design.

Connecting Lasersaurs

Besides the small and standardised objects that are the building bricks for the Lasersaur there is a whole actor-network which enables the repetition of the Lasersaur in the regions above. Much work to build and sustain heterogeneous relations is part of the Lasersaur assemblage and enables the design and knowledge to be held stable in network spatiality. This is more than regional space, since 'any given interaction seems to *overflow* with elements which are already in the situation coming from some other *time*, some other *place*, and generated by some other *agency*' (Latour, 2005, p. 166). Tracing these overflowing relations traces the network that makes the Lasersaur an immutable mobile.

A central element in the Lasersaur assemblage is the 'manual' (http://www.lasersaur.com/manual/, accessed 11.04.2014). The manual is not one document. Rather it is the umbrella term for the different forms of information about building the Lasersaur that Addie and Stefan assembled on their homepage for anyone to read. By now, the manual is an impressive extensive document of the production and circulation of knowledge that has been taking place in the Lasersaur project. But this took time to develop. When the prototype was cutting, the manual was rather rudimentary. It was enriched through the further design work of Addie and Stefan and the feedback they got on building the machine from others. When certain design changes were effectively tested by the two or other members of the community Addie and Stefan further worked them into the manual which so far has 16 revisions. A lot of work of transforming (email) conversations, experiences with building and experimenting with documenting a building *process* into a well structured manual has been made durable and accessible online.

Crucial, for the transformations of the manual, Addie and Stefan said in our interview, has been the social character of the project. When they built the second Lasersaur together with students at Culture Lab, they learned a great deal about how other people approach the building process and encounter difficulties. In a similar way, later on builders gave 'feedback' due to questions via email about building the machine and one could include answers in the manual. When the heterogeneity of the community increased with more less technologically skilled people joining, the demands to the manual increased as well. Whilst Addie and Stefan want the Lasersaur to be repeatable as easily as possible, 'opening up' knowledge to a diverse public requires learning and effort and a manual with more details. Although their home-base is in Innsbruck, the mobility of Addie and Stefan has therefore been crucial for the Lasersaur project. In 2011 they worked at Culture Lab and at HyperWerk. They presented the Lasersaur at a MakerFaire in the US, a popular event in the 'maker movement' and even won an award. They got invited by universities and FabLabs (or hackerspaces) to give talks. By now there are several examples of school classes building a Lasersaur – which shows that such effort pays off.

Till, who had already been experienced with mechanical technology, built the third Lasersaur with pupils. Two aspects of the then rather limited manual helped him a great deal in building. A CAD model, a digital technical drawing, Stefan had created along with the prototype, and 88 photographs that were taken during the assembly of the second machine and put online (https://secure.flickr.com/photos/stfnix/sets/72157626580353027/, accessed 11.04.2014). These provided much of the information for putting the hundreds of standardised industrial parts, he had bought for several thousands of Euros, together into a working laser cutter. The remaining information was provided by these parts themselves.

For Addie and Stefan a lot of the development process involved finding suitable parts for the machine and uncomplicated design solutions that were easy to realise. These tasks were strongly supported by other open source hardware projects where certain mechanical parts and configurations had already been tested and suppliers suggested and these suggestions were available online – forums and mailinglists again are crucial here as in the Lasersaur itself. Therefore, a central part of the manual is the 'bill of materials' which lists all the parts needed – from screw to laser tube – to build a Lasersaur and this document even suggests suppliers with whom Addie and Stefan had made good experiences. Producing the bill of materials has been such an important task for Addie and Stefan that they even started an open source software project based on their experiences to facilitate this process (http://www.bomfu.com/, accessed 17.04.2014). In an interview the two said that they see the bill of materials as the centerpiece that differentiates open source software and Hardware projects since it establishes the necessary link between the open source design and the materials (http://eyebeam.org/press/media/videos/open-art-fellows-nordt-labs-discuss-their-project-bomfu, accessed 17.04.2014). The bill of materials even exists in an US and an EU version since different vendors for such parts are operating there. If one tries to order from other vendors, as was the case in the FabLab's build with the aim to save money, the Internet is crucial to find sources for sometimes very special parts. A small group of members invested dozens of hours to find suppliers and used parts already in someone's or the FabLabs ownership, yet, we saved approximately 2000 € in comparison to the suggested vendors in the manual. This shows, however, how the Lasersaur depends on industrial objects and their capitalist geography of world-wide shipping and movement. Finding these commodities and bringing them together is crucial for building open source objects. These about 1000 standardised parts form the robust and mainly cheap building blocks for the machine. A fully open source version of a machine like the Lasersaur with all parts being designed and built in an open source approach is still a thing for the future.

Fully open source, however, is the software operating the Lasersaur, the 'LasaurApp' (https://github.com/stefanix/LasaurApp, accessed 12.04.2014). This is the interface between PC and laser cutter and steers the motors and the laser beam to cut what is shown graphically on the PC. Addie and Stefan used software of the RepRap open source 3D-printing project, which was steering 3D-printers, as the foundation for their app. The software is based on Linux and therefore is the most direct link to the early days of the open source culture. Similar to other design decisions, Addie and Stefan took the easiest version of this software to make it more accessible to people not that skilled with modifying software.

Skill is crucial in open source hardware, yet it must not be located in people alone. Rather it lies and flows in the 'correspondence' (Ingold, 2013) of objects and user/maker. Till encountered many difficulties at the beginning with the software for the machine and it took him several weeks and the help of friends skilled in software development to have it running. There are different areas of expertise and the demand, which is part of open source hardware projects, to be or become skilled in many ways (technical, social, etc.) is demanding. Yet, this points to another important aspect of the network spatialities of Lasersaur: the local conditions are important in many ways to support the assembly of the machine. One has to have the money, the basic skills, the tools, the social support, the space and the energy and time to assemble a Lasersaur and to assemble the local conditions with the Lasersaur assemblage. In the FabLab a group of about 5 people spent about 8-10 full working days to build the Lasersaur and have it running. Form my own experience as part of this group I can say, however that such effort in participating in the Lasersaur network pays off. Although, I wasn't an expert on building machines by now I'd consider myself able to build and repair all things mechanical in the Lasersaur since the correspondence with the object changed me. Yet, transcending local conditions and the actual parts of the Lasersaur themselves, there are other entities crucial to the way knowledge is being produced and circulated to enable such learning in the first place: the Internet itself, digital cameras to produce images, measuring and other standards, and so on. Bringing these all together in a network is an enormous task. As Addie said: 'if you're working with multiple countries getting something in the US is different than getting it here [...] and then there's metric versus, so all these different ways of measuring and that stuff these little things are very like hard to translate internationally' (Addie and Stefan, transcript, p. 3).

The Lasersaur manual is characteristic of many aspects of the Lasersaur and other open source projects as it condenses as a central node in the network. The manual gives security warnings, describes the building process, gives advice for operation and maintenance of the machine and explains how to get help or inspiration, e.g. on the mailinglist. Due to these manifold aspects of documentation that have been building up, the manual aims to cover almost all aspects of technical reality, to recall Simondon once more. Whereas 'user manuals' or 'operating manuals' for industrial objects may also be rather advanced, they typically cover information on how to use finished objects, and not about building or maintaining or even changing them. A member of the FabLab made a striking comparison between Lego and the Lasersaur. In both you assemble standardised parts with the help of a detailed description. Whilst play is still important in the Lasersaur, in important ways it still differs from Lego, however. In Lego the building manual comes prefabricated; in the Lasersaur it had to be produced along with more people building the machine. And furthermore, this is not a toy but a full fledged machine. The Lasersaur project, accordingly, has been successful in being supported by and building a network that produces a transgression of boundaries that industrial circuits of technology have powerfully set up. The Lasersaur's network enables connections between certain aspects of craftsmanship, industrial circuits and global flows of cooperation and information made possible by the Internet. It is the network, that enables many aspects of technology related actions – design, production, use, maintenance, modification – to take place in the regions where Lasersaurs stand. In the next section I consider why this makes the Lasersaur also a 'soft' and changing fluid object.

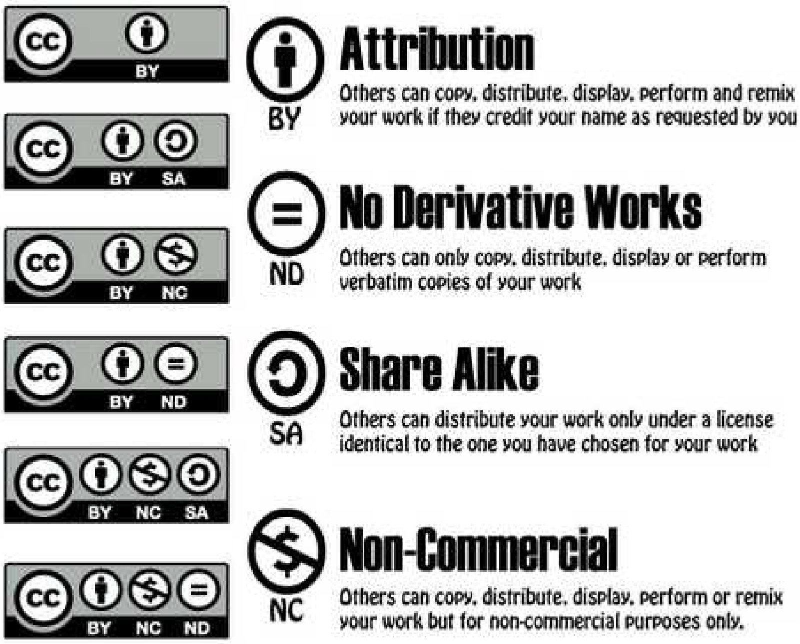
Transforming Lasersaurs

Fluid objects don't have the rigid control of networks that hold objects in a certain shape. Fluid objects are rather like fluids that flow. They hold together, yet they constantly change as they move along and flow around other entities or mix with other fluids. Fluid objects paradoxically stay the same because they slightly change, they are 'mutable mobiles'. Law and Mol (2001) took this argument from an ethnographic study of a water pump in Zimbabwe that spread into many villages, yet never really was the same. Its public design (almost a kind of an open source hardware water pump) allowed for all kinds of changes in the object and in its social relations (Laet and Mol, 2000). More explicitly than in regional and network space, time plays a crucial role to configure fluid objects and their flows. How does Lasersaur flow?

Ambient assemblage: open source licencing

Important in making open source hardware objects flow are legal licences that help to avoid certain effects of copyright and patents, both rather known to suppress the change of objects. From the early days of Free Software onwards, the legal aspects of open source have been a crucial issue for activists and researchers. This often led many to see Open Source practices mainly as a critique of intellectual property (cf. Berry, 2008; Coleman, 2012; Kelty, 2008). Nowadays there is a huge variety of licences that keep immaterial objects (software, images etc.) public in a legal sense. One of the most successful projects here is Creative Commons, a US based non-profit organisation which has been working on legal licences that support 'copyleft', i.e. the free and continuing public sharing of cultural works (Linksvayer, 2012). Lasersaur uses these licences for the manual. The normative and discoursive links and the licencing, which provides a certain fit to national legal regimes, could travel into the Lasersaur assemblage via logos of and references to Creative Commons licences which are available online (www.creativecommons.org).

There are still only few open source licences that explicitly address hardware and the different legal issues when it comes to intellectual property and material objects. The first open source hardware licence is considered to be the TAPR OHL (Tuscon Amateur Packet Radio Open Hardware Licence) which was released in 2007. It is, however, the massive spread of open source hardware objects that engenders much discussion and certain projects that aim at producing novel licences or to establish best practices of licence use (https://en.wikipedia.org/wiki/Open-source_hardware, accessed 20.01.2015). Open source licencing and discourse about it certainly is an important aspect in the global open source assemblage that challenges the seeming naturalness of intellectual property which is a political-economic and legal construct. Yet, as this study aims to show, for making sth. really open source, legal arrangements are not enough. Rather open source knowledge has to be practically produced and circulated on many dimensions.



Considering the technological side of Lasersaur, the machine is designed to allow for changes in many ways. The modular design makes it possible to depart with many parts from the bill of materials and modify the laser cutter. For example, there exist 100W, 40W and 150W versions of the Lasersaur with different cutting strengths. A French art school simply built a drawing machine by replacing the laser with a pen (http://numerique-tendance.tv5monde.com/152_projet_voir---ecran---voir, accessed 13.03.2013). It's also rather easy to change the size of the machine. Such changes, however, can sometimes lead to problems in the machine and cause extra work for the community. Stefan told, how the change of the cooling system for the laser by one member of the community caused a failure in the machine that was extremely hard to track down, since, at first, no one thought of the 'non-standard' cooling system. Yet, such technological modifications or 'derivatives' of the design are encouraged by the discoursive coding of the Lasersaur assemblage and Addie and Stefan reported that they were happy that such modifications have been increasingly taking place since the start of the third year of the project. As the introduction to the manual says 'an open source design can improve over time through the collaboration of many people. We hope in three years it will have evolved to the point where it has multiple robotic arms sticking out capable of building space stations :)' (http://www.lasersaur.com/manual/, accessed 15.04.2013). Although partly a joke, this links in to the hacking culture which highly recognises and values creative modifications of technology (e.g. Coleman, 2012).

Such modification of technology, however, from the beginning aimed also to be the modification of the social uses of technology in the Lasersaur project. The goal to have a comparably cheap yet reliable laser cutter was also the goal to get it into the hands of people that wanted one but couldn't afford it. The normative production of the public open source design should produce the normative public spreading of the machine itself and thus add indeterminacy to laser cutting technology: it should become experimentally appropriated through other-than-industrial uses. When Till was building his Lasersaur with school children, Addie said, that was what they wanted. For Mischa at HyperWerk, the Lasersaur was an important educational project for his students to show them the possibilities for their own future work. In FabLab Karlsruhe the Lasersaur has been strongly used by people to build all kinds of things.

At HyperWerk, as I indicated above, there is another industrial laser cutter which the students have been used work with. Next to it, the Lasersaur isn't used that regularly. The industrial laser is better integrated into the everyday routines and the network of objects that co-constitute them. As Mischa said:

> '[The Lasersaur is] a different tool really, that's exciting […] it's a beautiful object but it never really was accepted by the students. Uhm, it demands a different understanding. There is this dogmatic open source mentality, such that now you should change everything to svg format [an open source standard for digital graphics] instead of using illustrator [software by big US company Adobe], what every reasonable human does. […] It's somehow sectarian and that's also the allure, you feel part of a movement. […] It's reasonable with the general argument to not be dependent upon [big companies] but if you want to simply laser some paper in your everyday work it's inconvenient. […] Yet once in a while there are such freaks like the student who just finished who developed this [modification for Lasersaur to cut bamboo …] He worked on this really cleverly and handed it over to the [Lasersaur] community. And he was really happy to work with such an open source thing and he believes in it […] I think that was a good experience.' (Mischa Schaub, transcript, pp. 5, 6, 7)

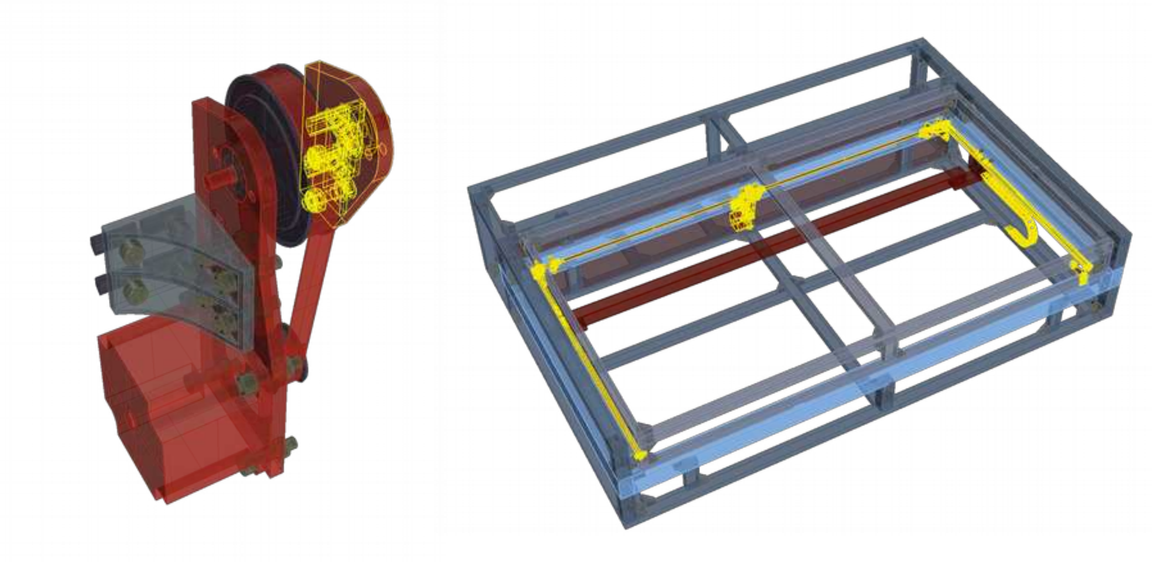
In some cases the Lasersaur might deliver a less easy use experience, yet to frame it simply as an object-to-be-used does not really get at what the Lasersaur is; This is what Mischa hints at. Being part of the 'sectarian movement' means trying to change the objects that co-constitute everyday life, be it in terms of using the open source software you're not that used to or to deal with the Lasersaur in more-than-use ways. Knowing objects like the Lasersaur involves 'a sense of bondedness or unity (an identity feeling) with objects, a moral sense (the oughtness of approaching them in certain ways), and states of excitement reaffirming the bondedness' (Knorr-Cetina, 1997, p. 20). Similar to Mischa, Addie and Stefan and Till were wondering in the interviews how to meaningfully frame the Lasersaur. Addie and Stefan saw the Lasersaur at the beginning as a tool that they wanted until they found out that it is much more. Now, ironically other people use it as a tool much more than they do, since their task has become the ongoing support of the transformations of the project. Till wondered, whether other people actually wanted to make the Lasersaur a perfectly working tool for everyday work or if they wanted to modify it in different ways. He contended that one needs a special understanding to take on open source objects.

As the Lasersaur flows into and along people's lives, it also starts flowing beyond established routines and meanings. And the Lasersaur's flow pushes the people who respond to it also partly outside the routines and meanings they have established with and for other objects. In short, flowing with the Lasersaur transforms the people as well. Much more than simply using this machine, engaging with the Lasersaur project is a process of learning, i.e. a process of change. The anthropologist Tim Ingold, building upon Deleuze, has most thoroughly argued for such an entanglement of the becoming of human beings and the becoming of artefacts through making. Contrary to the dominant idea of hylomorphism, which states that humans impose pre-conceived form onto dead matter, Ingold argues for a transformatory process that takes place in between humans and things. Building a Lasersaur is becoming-with the growth of the artefact, a process Ingold calls 'correspondence'. 'To correspond with the world [...] is not to describe it, or to represent it, but to *answer* to it' (Ingold, 2013, p. 108). Accordingly, in the correspondence with the flows of the Lasersaur assemblage people grow into knowledge (cf. Ingold, 2013, p. 13) which is itself a distributed and growing emergent effect of the assemblage.

The knowledge that flows in between Lasersaur and people is not simply technical knowledge and social skill, it also grows imaginations and hopes. At HyperWerk they were already working with other open source projects before they took on a Lasersaur. Yet, for Mischa, the Lasersaur was an inspiring demonstration of what is actually possible with open source and the real-time cooperation mechanisms upon which it is built. Of course, the flows of Lasersaur were only some amongst other flows with which Mischa moved along but since 2013 a Lasersaur has been standing inside 'motoco'. This is HyperWerk's largest recent project with the aim to transform an old 32.000m² factory building in the stricken region of Mulhouse into a centre for creative work and fabrication. They have chosen open source to be one of their guiding principles and Mischa stressed that this seems to be the crucial task now to use collaborative openness as a way to organise such spaces. 'motoco creates equipment, furniture, tools, methods, structures, rules, manuals, networks, media, skills and strategies for design under postindustrial conditions. Results of motoco are open-sourced, actively shared and for free' (http://motoco.me/motocomulhouse/, accessed 17.04.2014). It is also in such ways that a fluid Lasersaur corresponds with the world.

As more open source projects and objects have been emerging, people have increasingly started to imagine whole networks of open source that could in the near future co-constitute much of social life. In 2011, for example the project 'open source Ecology' included the Lasersaur into their set of machines with which they want to create an 'open source civilisation'. The project has been building prototypes of machines for modern farming since 2003 and in 2006 started the 'Global Village Construction Set'. A 'set of the 50 most important machines that it takes for modern life to exist [...] a modular, scalable platform for documenting and developing open source, libre hardware – including blueprints for both physical artifacts and for related open enterprises' (www.opensourceecology.org/about-overview/, accessed 04.04.2014). This set shall provide machines that can build other machines – and the Lasersaur shall contribute to this. Open source Ecology is clearly the most 'utopian' project in the recent open source scene that I have come across. It has strong similarities to the technovisionary communes of the US counterculture in the 1960s and 1970s (cf. Turner, 2006). Yet, it has also become one of the most prominent open source projects; it received a lot of funding and donations and attention in

Ambient assemblage: CNC and CAD – from design to sharing



(http://www.lasersaur.com/manual/build/6.y-drive.html, accessed 15.01.2015)

The pictures above are from the Lasersaur manual. Since the end of 2014 they can be viewed in any internet browser. Before that the way to see these technical drawings was in CAD (computer aided design) software programmes of which there already exist open source versions. From the first Lasersaur version onwards the CAD model included all parts and their relation to each other. Zooming and rotation of the graphic allow builders to see in detail how the parts need to be assembled and what the measurements of the machine are. In our build at FabLab Karlsruhe the CAD graphic was the most imporant information that guided the actual building process.

Software and its configuration in digital technosocial arrangements is absolutely crucial for open source hardware. On the one hand, these CAD graphics show how it is possible to move information in software very stable through the Internet and how this information can be enriched with new features in a CAD programme rather easily. On the other hand, CNC (computer numerically controlled) machines are fed with and controlled by software. To make the Lasersaur cut a simple graphics programme and the Lasersaur firmware are enough to turn a two dimensional drawing into a command to laser sth.

Yet besides, designing and controlling machines software is a key ingredient in novel technosocial arrangements that are key to digital fabrication and open source hardware. People started to upload these designs of objects that CNC machines can produce to online platforms – the most popular so far is Thingiverse, part of MakerBot Industries which began as an open source 3D-printing company (www.thingiverse.com, accessed 12.04.2014). The mainly free design files, most of which are for 3D-printers, but there are hundreds for laser cutters, can be downloaded and modified and sent as instructions for the manufacturing process to the machine. This is one reason why Addie and Stefan consider the Lasersaur as an infrastructural project, based on which many other projects can grow. Software connects machines and people globally. It is easily multiplied, moved about and shared. 'Everything translatable into digital language and reproducible or communicable at no cost tends irresistibly to become common property [...] when it is accessible to – and useable by – everyone' (André Gorz, 2010, p. 11). The technosocial arrangements of open source hardware are in a way themselves a computer aided design.

the media – even Noam Chomsky has noticed it.

Addie and Stefan were strongly inspired by the modular approach to building a whole system of things and machines – they also see the Lasersaur as an infrastructure, an enabling platform for other open source hardware. Such fluid modularity has also been crucial for the Lasersaur itself which is based on many 'pieces' of other open source projects (in technical and conceptual ways). The electronics and software of Lasersaur are based upon open source projects which furthermore provided much conceptual inspiration. To acknowledge this, the Lasersaur homepage states: 'Mad props to reprap.org, www.cnczone.com, arduino.cc, grbl, buildlog.org, and their giants' shoulders.' (www.lasersaur.com, accessed 24.04.2014). There is much learning from each other and mutual observation of other open source projects. Drawing upon parts of the Lasersaur design, a very small open source laser cutter was already being created (http://www.smartdiys.com/smart-laser-mini/, accessed 04.02.2015). In November 2013, Marcin Jakubowski, the founder of open source Ecology stayed over at Addie and Stefan's studio in Innsbruck to build a Lasersaur. But besides building they experimented with novel forms of documentation of the building process, i.e. filming each step of the assembly and sharing materials with novel online platforms (www.opensourceecology.org/ose-lasersaur-build-documentation-sprint/, accessed 04.04.2014). Yet, besides such continuous flows of the object and its environments there are ruptures and jumps that change the Lasersaur and turn it into another kind of object.

Burning Lasersaurs

Besides regions, networks and fluids there are fire objects. Law and others elaborated this type of objects to take into account the discontinuous which is not present in the other types. To understand fire objects one has to

> 'think of them as sets of present dynamics generated in, and generative of, realities that are necessarily absent. [...] Such objects are transformative, but the transformations [...] take the form of jumps and discontinuities. In this way of thinking, constant objects are energetic, entities or processes that juxtapose, distinguish, make and transform absences and presences. They are made in disjunction. Fire objects, then, depend upon otherness, and that otherness is generative' (Law and Singleton, 2005, pp. 343–344).

Important to understand fire objects is to not to simply see multiplicity and otherness as an effect of different interpretations, or simply as different sides of the same 'boundary object' (Star, 2010). Fire objects are multiple in the absences and presences that they co-constitute, they are plural, messy objects. What are the structures of presences and absences in the Lasersaur assemblage?

There is a certain structure in the assemblage itself that withdraws elements from other elements. Whilst this is a general ontological characteristic of assemblages, that the whole assemblage is never present within one element, this is significant in open source assemblages. Each Lasersaur is based upon the work of many people who are not present at the site of a specific machine. Whilst there are interactions and communications with other people, everyone I interviewed didn't know who most of the other people were that contributed to the Lasersaur, why they do this and how they use their machine. Despite the rhetoric of openness, much remains opaque. Otherness, the other, is always present/absent in open source assemblages. Yet, it is integrated via the plurality (e.g. in versions and forms of use) of the technological object being the smallest common denominator between those who remain other to each other. Here, however, in the co-constitution of indeterminate technological object and sociality lies a key normative aspect of open source assemblages. When asked what they understand as open source, Stefan answered:

> 'It's a way of collaborating, and what's very important about it, you know, it sets up a set of expectations. [...] What happens when you collaborate what happens when you, you know, put your work in, and how can you proceed? So the expectation is that it stays in the public domain, and this allows a different collaboration model a different way of collaborating than if you don't have these expectations.'
>
> Addie added: 'open source is kind of this idea, it's a way of working I don't know whether it's necessarily a tangible thing, it's kind of like how do you define art or how do you define happiness, it's there, it's a grey area and there is not the fine line of what is right and what is wrong with open source. For me, it's this idea that you collaborate and release your ideas freely so that other people can share them' (Addie and Stefan, transcript p. 1).

In releasing their vision for the technological object into the public domain, Addie and Stefan took a first step to give away control over their idea and to build the expectation that this is OK to do for others as well. This is an invitation for others to co-determine the further unfolding of the technological object without knowing everything. Trust is thus an important aspect that co-constitutes open source assemblages and these in turn strengthen or weaken it. This includes accepting what others might do or not do with the technological object, and accepting that one doesn't know sometimes. Coleman, who argues that liberalism is central to Free and open source software, showed how normally 'big politics', e.g. the aim to build an alternative to capitalism, is absent in open source software projects. The politics center around 'free' software, a public technological object that shall be produced and further unfolded. Therefore, this object can participate in many different contexts of meaning (Coleman, 2012, chapt. 4 and 5). Open source assemblages thus not only embody a solidarity with and openness towards unknown others, it is in turn also the absence of others which is generative of the presence of a plural technoepistemic (fire) object.

Crucial for this technological object is that from the beginning of the project industrial laser cutters were present because they were absent. Addie and Stefan wanted to develop an affordable laser cutter that could move into contexts where industrial lasers wouldn't. Furthermore, the machine is partly made of parts that are used in industrial lasers, yet in the Lasersaur they assemble into something else. And this something else is being made through relations that actively depart from the relations that an industrial laser cutter would engender. The Lasersaur's (and other open source assemblages's) significance lies in the othering it produces concerning the dominant relations between people, knowledge and objects. The presence of the Lasersaur makes some aspects of these relations absent. Yet, these also make the Lasersaur partly absent, e.g. prevent its even further spreading across the globe. In a way, the presence of each one relies on the absence of the other. This, however, is not a simple either or alternative. It is a process of making present and making absent, of producing otherness. When a Lasersaur enters certain projects or contexts, normally there is no neat fit into established routines.

This is especially so since a laser cutter is complex and potentially dangerous. Before, during and after the actual building of a Lasersaur, safety was a prime issue in FabLab Karlsruhe. Even the reflections of a 100W laser beam could easily blind people or harm them otherwise and the electric current could create lethal electric shocks. Although there are many safety measurements in the Lasersaur design it is still a question of applying them properly in the process. And since the Lasersaur was to be used in a public workshop some people in the FabLab were extra cautious to make sure that the machine was built and operated safely and in accordance to certain industrial safety standards. Addie and Stefan also encountered much criticism at the beginning which centred on open sourcing such a dangerous machine. They emphasised, however, that actually building a Lasersaur helps people to operate it properly. Thus, whilst I couldn't find any reports about serious accidents with the Lasersaur, its dangerous side is present when people approach this object. In a way, the Lasersaur's fire in a literal sense is latently present and part of the object, although much effort is being made to keep it absent.

Whilst accidents are a probable possibility of Lasersaurs they also engender other possible futures, futures that might imply larger technosocial change. Whilst a fully supportive regime of (Open Source) people, knowledge and objects is not there to seamlessly integrate Lasersaurs, imaginations have started to circulate that hold such a regime to be ever more possible (e.g. Open Source Ecology). To put it succintly: Whilst the Open Source civilisation is absent, there increasingly are tendencies (like the Lasersaur assemblage) that, in combining imagination and practice, increase Open Source possibilities to further unfold. I do not claim that this is a simple linear adding up. Tendencies are indeterminate, they are not the laws of history (see Bloch, 1995; Stiegler, 2010), in a way they are also fires that heat up and withdraw. 'The unbounded otherness of undomesticated fire, we insist, is generative. It is productive. It depends on and creates the unknowable and the unexpected. [… I]f objects are both present and absent, then we cannot know or tell them in all their otherness. Things will escape' (Law & Singleton, 2005, p. 349). Stefan gave a hint, how his hopes, inspired by the Lasersaur, were sometimes similar to fire:

> 'We talk a lot about how powerful personal fabrication is and the Lasersaur being one of those canonical machines for personal fabrication. How much does it enable people to do things and invent new things and we kind of go back and forth. It's like, oh, you know, everything is gonna be invented in this way and locally produced and at other times it's like, oh, some things are so complex you can't possibly, like, cultivate that knowledge locally. If you really look into industrial processes some of them are so advanced that it's hard to imagine how you bring them to local production. [...] I really go back and forth between, like, this is totally possible [...] it's sort of this paradigm change that happens. And sometimes I feel like, uh woah, this is never-, how do you manage this? How, you know; you need like a dedicated group of people and that's all they do' (Addie and Stefan, transcript, p. 28).

In being already different to the dominant ways how technology is being produced and used, the Lasersaur hints at a potential shift, an imagined possibility of large scale social change, the 'paradigm change' that Stefan talks about. Although such a shift is absent, its prototypical, experimental, hypothetical forms are noticeable in assemblages like the Lasersaur. And with ambivalent experiences being made, hope for this shift is present/absent. As a fire the Lasersaur is generative of transformations, challenges, difficulties, chances, novel skills, or more generally of the new that embodies a significant difference to what exists. There is a potential for othering, for making different, that the Lasersaur offers – partly visible, partly concealed. Yet, playing with fire and not burning oneself or extinguishing it requires people, that actively seek the potential othering, the making different, that the Lasersaur offers. With Ernst Bloch I'd like to say, it needs people, who 'learn hope', 'people who throw themselves actively into what is becoming, to which they themselves belong [...] Thinking means venturing beyond. But in such a way that what already exists is not kept under or skated over [...] it grasps the New as something that is mediated in what exists and is in motion' (Bloch, 1995, p. 3–4). In its fire way of being the Lasersaur assemblage hints at a 'real future' (Bloch), one which departs from a simple prolongation of the present, but one not-yet completely born. And this sense that some jump in history, some paradigm shift might be latently under way, is crucial to understand the technoepistemic culture of open source hardware.

The technoepistemic culture of open source hardware

By now I saw three assembled Lasersaurs and many others online. Each of the builds standing in rooms make clear that they are special objects. Edgy yet elegant, the machines show their cables and screws and the aluminium parts of the frame which all look similar. It is as if the machine is literally 'open' with holes in its surface that present the inside. Instead of hiding them under a neatly designed and closed surface, the Lasersaur presents the objects that made it up. It shows its relations to standardised industrial objects that helped to turn it into something special. Although, the aesthetic design of the Lasersaur owes most to functional criteria, it departs form mainstream industrial design. Normally, the surface hides the inner workings of objects and suggests that the object is one unified entity (Anusas and Ingold, 2013). With its open appearance, the Lasersaur, even as a stable entity in a room, points at the flows of other objects and work that put it together. And these flows and relations are what makes the Lasersaur an open source object, entangled with a particular technoepistemic culture that centres around the unfolding of such objects.

At the beginning of this text I cited the definition by the OSHWA which stated that open source hardware are tangible artefacts 'whose design has been released to the public in such a way that anyone can make, modify, distribute, and use those things' (http://www.oshwa.org/definition/, accessed 14.12.2014). The text then showed how such release is practiced in the Lasersaur assemblage and how this entails much more than simply putting a design online under a certain licence. Open source objects emerge as part of assemblages, processes that bring different elements together and change them. I showed how this entails visioneering and prototyping both, object and project, how different relations between people, objects and knowledge are being productive of different versions of the Lasersaur and how Lasersaur assembles within a much larger assemblage and technosocial landscape. This has been preconfigured by the cultures of hacking and open source software. And there is the wide spread of open objects (Simondon, 2009) which enable such practices and are being unfolded by them. But open source cultures explicitly radicalise the openness of these objects and thus are special and significant technoepistemic cultures. The recently emerging technoepistemic culture of open source hardware has been transforming the open source landscape in multifarious and important ways due to drawing other people, knowledges and objects into open source practices – and in turn transforming these practices.

As this text claimed, technoepistemic cultures have to be investigated with the object that they unfold and with which they are entangled. There are many different technoepistemic cultures and in turn different particular ensembles of objects in them, yet the open source hardware culture described here along the case of the Lasersaur project has special relations to ensembles of open objects. Predominantly, open source objects are not unified entities, instead they are networked and multiple. Their being open is an effect of particular configurations of the assemblage of which they are a central part. The Lasersaur assemblage was produced by, but also had to further produce particular topological relations between people, knowledge and objects. It is an almost global project with 'dependencies' in regions all over the world. Between these, knowledge is able to move rather stable thanks to the network that was produced. Yet, there are profound changes along with the movement of the fluid technological object which engender processes of experimentation and learning. The Lasersaur as fire is thus very significant in the otherness that it is compared to established relations between people, knowledge and objects. Accordingly, the opportunities and skills to participate in such an assemblage and influencing it are utterly important for this technoepistemic culture. Here one can think of, amongst other things, knowing how to create and participate in (mainly English speaking) mailinglists and social media, how to document technical knowledge with digital tools (CAD programmes, cameras), how to organise building materials and even how to practically deal with the force and energies of imaginations.

A key aspect that enables such assembling of open source hardware assemblages is modularity, i.e. the availability of components that can be linked together to greater or lesser extent. First, there is modularity in technical terms. Besides standardised industrial objects as mainly cheap and widely available building blocks, there are an increasing number of open source projects on whose knowledge and technical objects one can draw. The latter, however, is not in itself a seamless fit. One has to learn to relate to other open source assemblages and their specific ways of producing and circulating knowledge and objects – this can also go wrong or be impossible. Whilst technical modularity is an enabler and producer of building blocks, there is no overall standardisation and smooth and easy connection. Making use of such an imperfect modularity requires work and learning. However, some larger projects such as Linux and Arduino seem to have a wide distribution within the global open source assemblage. Technical modularity, however, is not only the result of practical concerns and often small resources in such projects. It is also at the centre of the ethics of free and open source knowledge. Open source knowledge shall be publicly available for others to draw upon. Second, modularity is also important in 'social' terms. Open source hardware assemblages draw upon already existing services, objects and media that enable the forming of groups and the communication amongst them. Furthermore, in drawing upon the knowledge of the many in such groups there is a certain modularity of knowledge and skills that are meant to add up. Not everyone has to be able to create knowledge about each step in an open source assemblage, yet almost everyone is required to use the knowledge that is being created by others and to make this correspond with their local contexts and open source objects.

Such linking up of assemblages is particularly important to the dynamics in this technoepistemic culture as I want to argue once more with the Lasersaur. Its assemblage and its lines of becoming move and transform in multifarious ways which owes a lot to the 'contexts' that start relating to the Lasersaur over time. Each element that passes in and with the assemblage is not determined by it and has its own distinctive pull and energies which contribute to modifications in the overall assemblage. Such pulls and energies are strongest concerning the people, organisations and projects that Lasersaur assembles, yet they are not reduced to them. The Lasersaur assemblage is driven by 'networked projections' (Flusser, 1994, p. 144, my translation). Such projections are not only imaginative goals but also themselves assemblages with a 'material' basis. With their start, however, these projections 'become-with' the Lasersaur, they change, flow over or are being partly taken up by others. Based on such becoming-with the technological, imaginative and social realities of the Lasersaur move along or jump as emergent effects of the assemblage they are also building. The networked projections of the assemblage do not neatly integrate into each other, rather they produce creative tensions either amongst each other or in relation to their surroundings. And they contribute to the further unfolding of the technological object in technological, imaginative and social ways.

The openness the Lasersaur and other projects aspire to and have to produce is in a profound sense the making collective of the different aspects of technical reality: design, production, use, maintenance, transformation (cf. Simondon, 2009). Flusser argued that design in modern societies has tended to direct its attention towards the 'objective' aspects of technology and thus created many objects that are obstacles for other people.

> 'In the case of objects of use, I come across designs projected by other people. [...] Objects of use are therefore mediations (media) between myself and other people, not just objects. They are not just objective but inter-subjective as well, not just problematic but dialogic as well. The question about creating things can also be formulated in this way: Can I give form to my projected designs in such a way that the communicative, the inter-subjective, the dialogic are more strongly emphasized than the objective, the substantial and the problematic?' (Flusser, 1999, p. 59)

The Lasersaur is one attempt to answer this question along with many others in the open source assemblages around the world. Such dialogic processes, however, in project's like the Lasersaur depend upon making knowledge 'objective', actively creating objects that can travel with information between people, and making objects that correspond with people. In bringing together and arranging these elements open source hardware projects show the technosocial capability of creating such assemblages and their entangled open source objects. Thus whilst a laser cutter itself is nothing new, an open source laser cutter and its entanglement with an open source production and circulation process has been special and has created an open source laser which is different to its industrial cousins.

Here lies a crucial link of open source hardware assemblages to a society which is increasingly being arranged, changed and troubled by technoscientific processes. As Nordmann has argued, the key value in technoscience is to show that one is able to control a new technological capability (Nordmann, 2012). These capabilities increasingly create societal hopes and concerns and transformations. However, the society that values technoscience so highly is also a society ever more entangled with technological objects and environments (Hörl, 2013a). The technoepistemic culture of open source hardware is transversally located within this contemporary landscape. Its production of new technosocial capabilities and assemblages makes use of the overflowing technosocial possibilities in the present and arranges them together with technological objects, meanings, visions and practices to show that contemporary material technology can exist and unfold beyond the confines of industry. The latter seems stuck in the 20th century and mechanical arrangements when compared to the digitised fluidity of open source hardware technologies in almost cybernetic technosocial arrangements. This is how, in its complex relationality in imaginative and practical ways, the technoepistemic culture of open source hardware shows that 'another technology is possible' and based upon this 'proof' this culture draws new resources into its assemblages.

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