Lorenzo Davoli

TRANSTRUCTURES

Umeå Institute of Design
Umeå University

TRANSTRUCTURES

Prototyping transitional practices for the design of postindustrial infrastructures

Lorenzo Davoli

Umeå Institute of Design
Umeå University

Transtructures
Prototyping transitional practices for
the design of postindustrial infrastructures
Lorenzo Davoli

Dissertation for the degree of Doctor of Philosophy in Design
Umeå Institute of Design
Faculty of Science and Technology
Umeå University, Sweden SE-90187

Umeå Institute of Design, Research Publications, No. 004
Electronic version available at http://umu.diva-portal.org

This PhD was made possible with funding from the Umeå Institute of Design,
the UID Prototyping Practice Research Program, funded by Balticgruppen Design AB,
and the Satin Project, financed by EU structural funds, the administrative board of Norrbotten,
the Norrbotten County Council and the City of Luleå. Additional funding was received from
The Swedish Faculty for Design Research and Research Education, Designfakulteten, and the
JC Kempe Memorial Scholarship Fund.

Graphics and layout Lorenzo Davoli
Cover illustration: Linnaea Silfvergrip.
Proof Reading by James Barret
Images © Davoli & Redström

Printed by Pantheon
www.pantheondrukkers.nl

ISBN 978-91-7601-422-6

Contents

Abstract

This dissertation is about *'transtructures'*, a term coined to describe new kinds of infrastructures that are more attentive and responsive to the needs of contemporary society, its emerging economies and technological capabilities. The purpose of this inquiry is to begin to explore the character and possibilities of a design practice that could guide responsibly and ethically the transition of existing industrial infrastructures towards these new configurations: what processes it could follow, and what materials it could include. Through a series of design experiments in the areas of logistics and telecommunications, I started to prototype and develop a programmatic framework for a 'redirective' design practice, which is aimed at engaging publics with infrastructural issues. Design probes and speculative mockups have been employed to express and materialize present and future infrastructural configurations, opening them up to public scrutiny and participation. The premise of this work is fairly simple: if we want to provide more citizen-centered solutions to emerging social demands, we need to explore what changes are possible, and even required, within the industrial systems that currently frame our possibilities for implementing such innovations. Thus, certain design interventions will be necessary to allow people outside these systems to understand and relate to these networks and to identify possibilities for their transformation. The result of this inquiry is the early 'prototype' of what a practice for redirecting and transitioning towards the design of such postindustrial infrastructures could be like. In particular, it exemplifies how design may inquire into the artificial space of industrial infrastructures and explore opportunities for their reconfiguration toward more contextually adaptive forms and functions.

Acknowledgements

The interesting thing about finishing a PhD is the sense of bewilderment one feels one realizes that in five full years of studies he just managed to scratch the surface of things, and so much more is out there to still be explored. I probably did not go that far after all. But I can certainly say when compared to where I started I have reached a different level of consciousness in myself and my role as a practitioner and as a researcher. This personal growth however would not have been possible without the contribution of all the people I have interacted with during my studies and that have made my stay at the Umeå Institute of Design possible and memorable.

In particular, I am grateful to Johan Redström for his precious contribution and patience as a teacher and an advisor. His guidance has been fundamental to help me frame my curiosity and develop the necessary attitude, tools and depth to properly address the scale of my interests. I'd like also to express my gratitude to my secondary advisors Erik Stolterman and Anna Valtonen, for their input and assistance in the early stage of my PhD. Molly Wright Steenson and Heather Wiltse also deserve a special mention for their precious feedback and active participation in the development of this dissertation. I am also thankful to Maria Hellström Reimer and Pelle Ehn for their work and the essential teaching I received attending Designfakulteten and that contributed highly to the shaping of my critical thinking. Finally, a big thank you goes also to all my fellows PhD students that accompanied me in this adventure, Stoffel, Guido, Daniela, Tara, Camille, Monica, Aditya, Søren for the constructive discussions, conversations and fun we had along these years. A special thanks also goes to all the staff members of the Umeå Institute of Design for their help and patience; to our 'neighbors' at the Swedish Interactive Institute in Umeå; to Floda31 and all the participants and people that engaged with me, my designs exploration and their precious insights and accounts.

Lastly but not the least, I'd also to express my most profound gratitude to my parents Camillo and Olivia, who have taught me to follow virtue and knowledge, and gave me the privilege and opportunity to spend so much time on my education. Your inputs have been essential for my growth as a thinker and as a man and it is also thank to you if I am now more empathetic designer.

INTRODUCTION

We live embedded in a complex web of infrastructures. Networks of pipes, cables, data and protocols are the media through which entire states, companies and societies interact. Like an 'operating system', they function as the code that rules how and when information circulates, space and society organize and things take form (Easterling 2014, 13-14). In order to ensure progress and appropriate sustainability for our societies and economies, infrastructures need to evolve over time to meet new needs, adapting their forms and functions according to the changing cultural values and social demands. As do design practices, according to how they address changing socio-technical requirements.

In the light of current transformations, to critically question how design relates to different forms of production within the constraint of existing infrastructures —what futures they support or hinder— has once again become an important subject of debate and a matter of public concern. The social context and the consumption and manufacturing landscapes are in fact changing, thus exposing some of the limitations that consolidated infrastructures' top-down and bottom-up modeling approaches have for fulfilling the new condition. In particular what seems to be a challenge for design is how to not only evolve and critique its own practices in order to address new societal and technological needs, but also to influence and initiate change in its surrounding environment. That is, the underlying systems of industrial infrastructures within which design operates, today seem to be limiting and constraining the diffusion of innovations rather than enhancing them (Fry 2009).

As Jamer Hunt posits in "Manifesto for Postindustrial Design", we do not live in a manufacturing economy anymore[1], but in an information and service one where new organizational models and possibilities for interaction, enabled by digital technologies are transforming and undermining established modes of production and the development strategies typical of the industrial era (Hunt 2005). Beside the several possibilities for lighter economy, sustainability and alternative forms of organization that information and automation technologies potentially open up, however, the design of new systems and infrastructures continuously replicate patterns of scalability, control and reliance on physical assets typical of the industrial systems they try to antagonize (Winner 1989).

'Industrial habits of design' —a conservative force against change, in a Deweyan sense (Dewey 1954)— keep us conceiving of design as a problem solving activ-

1 For billions of people this is not the case, but in the developed, post-industrial world it is.

ity, aimed at facilitating access to commodities, through practices and processes that conceal the functioning and logics of the devices it produces (Borgmann 1987, 35).

This prevalent interpretation of what design 'is' and 'does' appears today to be limiting our possibilities to explore solutions to the social, economical, and environmental problems that characterize our postindustrial society. By limiting the scope of design to the fringes of present infrastructures, it prevents us from acknowledging the necessary changes required on their behalf to properly support new design configurations, thereby confining our research for possible answers within the current industrial paradigm of production. Economic system and development models that are already unable to guarantee social progress (Sassen 2014), and in which alternative ways of making and doing can resist only by being incorporated, or in other words, "once registered as diverging from the culture of industry they belong to it" (cf. Horkheimer and Adorno 2002, 104).

Transcending postindustrial dichotomies

Postindustrial is the term generally used to describe the shift from an economy based on manufacturing and material transactions to one based on the exchange of services, knowledge and data (Bell 1973). However, what seems to characterize this particular moment in history is a more complex condition, as a product of an interrelated set of phenomena and events of which the transition to a service and communication economy is just one aspect. Two main topics are pivotal in this discussion. The first one is an increase awareness of the social discriminations and inequities within the current development pattern and its impacts on the planet's ecosystem (Fry 2009). The second topic is the 'tension' between the still strong presence and influence of the industrial networks of infrastructures upon which we still rely on and the emergence of new postindustrial needs and possibilities for production and consumption (Dilnot 2015; Hunt 2005).

In this context, the progressive pervasive integration of information and automation technologies in any aspect of life contribute to highlighting these tensions, altering the established hierarchies of scale between products, infrastructures and governments; blurring the borders of public and private, and changing the relations between location and activities, labor and value generation (Easterling 2014; McCullough 2005; Mitchell 2003; Qiu, Gregg, and Crawford. 2014). As a result, a revitalized discussion about authority, sustainability, technological rationality and social organization, already characterizing the political and philosophical debates of the second-half of the previous century, recurred. A debate summarized by the architect and technology expert Anthony Townsend as the necessity to develop new civics and update our legal frameworks in the face of an increasingly pervasive presence of digital networks (Townsend 2013).

In particular, two antithetical models of organization and planning catalyzed experts and public attention in recent years. Renovated techno-utopian and top-down 'cybernetic' views of design started to be opposed to equally structuralist bottom-up visions of a more horizontal, networked and participatory society, where computers and handheld devices could provide the necessary platforms for more collaborative, sustainable and citizen-centered forms of governance and service supply.

After the economic crisis of 2008, concepts such as "smart cities" started to gain media and financial attention. Large corporations began promoting rational approaches to the environmental, economical and social problems produced by the "inefficiency" of the previous industrial era (Townsend 2013). To increase the overall sustainability and efficiency of cities and infrastructures, IT and engineering companies started to advertise ideas of 'smart' systems able to automatically respond and adapt to human behaviors and environmental contingencies through feedback mechanisms of sensors and actuators. These models however, were soon labeled as technocratic and reductionist and unable to represent a viable development strategy. In particular they were seen as an attempt to impose machine rationality on society, and a possible source of new types of social discriminations and exclusions (Crang and Graham 2007; Sassen 2011).

As a response to the standardization and low contextual sensitivity of these industrial-modeling approaches, a number of bottom-up, small-scale and sustainable systems for producing, sharing and accessing services and resources started to emerge (Manzini 2015). The success of these initiatives relies on their ability to meet situated needs and social demands industrial means of production and service-supply cannot fulfill anymore. Vital for their diffusion was the unprecedented accessibility of handheld devices, embedded systems, micro controllers, wireless communication networks and digital manufacturing tools that characterized the past decades. These technologies provided these old and new forms of bottom-up and social innovations with the necessary backbone to facilitate accessibility, coordination and use of their services.

These networks of locally based entrepreneurial initiatives and collaborative communities, are, in many ways offering an example of what the future of production might look like, by providing the possible foundations for more resilient infrastructures and distributed economies (cf. Fiksel 2003; Johansson, Kisch and Mirata 2005). Despite the ability to foster local economies and social fabrics, however, these efforts might not be alone sufficient to address present issues. If top-down systems and corporate organizations are limited by their slow responsiveness, adaptability and focus on economical and technical efficiency; their advantage is their clarity of purpose, their reliability and their global connectivity. On the other hand, the bigger flow of bottom-up innovations comes, paradoxically from their organic flexibility, variety and redundancy of standards. Bottom-up practices work as far as they solve a problem for small-defined groups, but fail when attempting to scale-up or generalize their solutions (Townsend 2013, 165).

The differences and political relations between top-down and bottom-up practices can be illustrated by de Certeau's definitions of 'tactic' and 'strategy' in 'The Practice of Everyday Life' (1984, 29-42). Strategies are expressions and structures of power adopted by groups in control of infrastructures and institutions. They are usually long term and define the overall purpose and rules of a system, privileging considerations of control, stability and efficiency. Tactics instead are used by those subjected to these rules, who, lacking the means and access to modify the institutions directly, make use of opportunities opened to them in order to juggle their limitations, improvising micro-political resistances. As such, bottom-up innovations share features more of a 'tactic' rather than a long term 'strategy' for development. As for tactics, the space of bottom-up innovations and postindustrial practices is the 'space of the other', the space planned and organized in function of industrialization and mass production. They are isolated actions that take advantage of the gaps left open by the industrial regime without having the ability and proper foundations to fully develop within it nor to keep it at distance (37).

As the philosopher of technology Andrew Feenberg explains, bottom-up tactics do have the capacity of influencing long-term change, but the kind of resistance they provide does not have the power to enable a paradigm shift per se: "Power is only tangentially at stake in most interactions, and when it imposes itself, resistance is temporary and limited in scope by the position of the individuals in the system. Yet insofar as masses of individuals are enrolled into technical systems, resistances will inevitably arise and can weigh on the future design and configuration of the systems and their products" (Feenberg 2000a, 228-229). The type of change that bottom-up innovation seems to provide however appears to be more incremental rather than divergent, as it often brings to light new measures of society and consumer's needs that are then appropriated by industrial capitalism (Winner 1989, 61-84). Once recognized as 'valuable', alternative ways of making and doing are inevitably subjugated to market forces, compelled to scale-up and find compromises in order to survive (cf. Cuartielles 2014).

The above observations concerning bottom-up and top-down relationships provoke questions about the types of infrastructures necessary to support these new social and economic activities without altering their qualities. Indeed, bottom-up innovation practices are fundamental to gaining knowledge about how to make things differently and provide society with more inclusive and adaptive solutions. As it stands though, they do not seem to represent a reliable alternative to industrial systems. Similarly, it does not seem plausible that

postindustrial practices based on the values of sociality, sustainability, flexibility and diversity could fully advance within industrial systems developed according to scale economies and standardization criteria. To move forward, the relationships between the local and global – the big and the small – require new types of supporting infrastructures capable of weaving new synergies and symbiotic interactions between industrial and postindustrial systems and their resource flows (cf. Thackara 2006, 226).

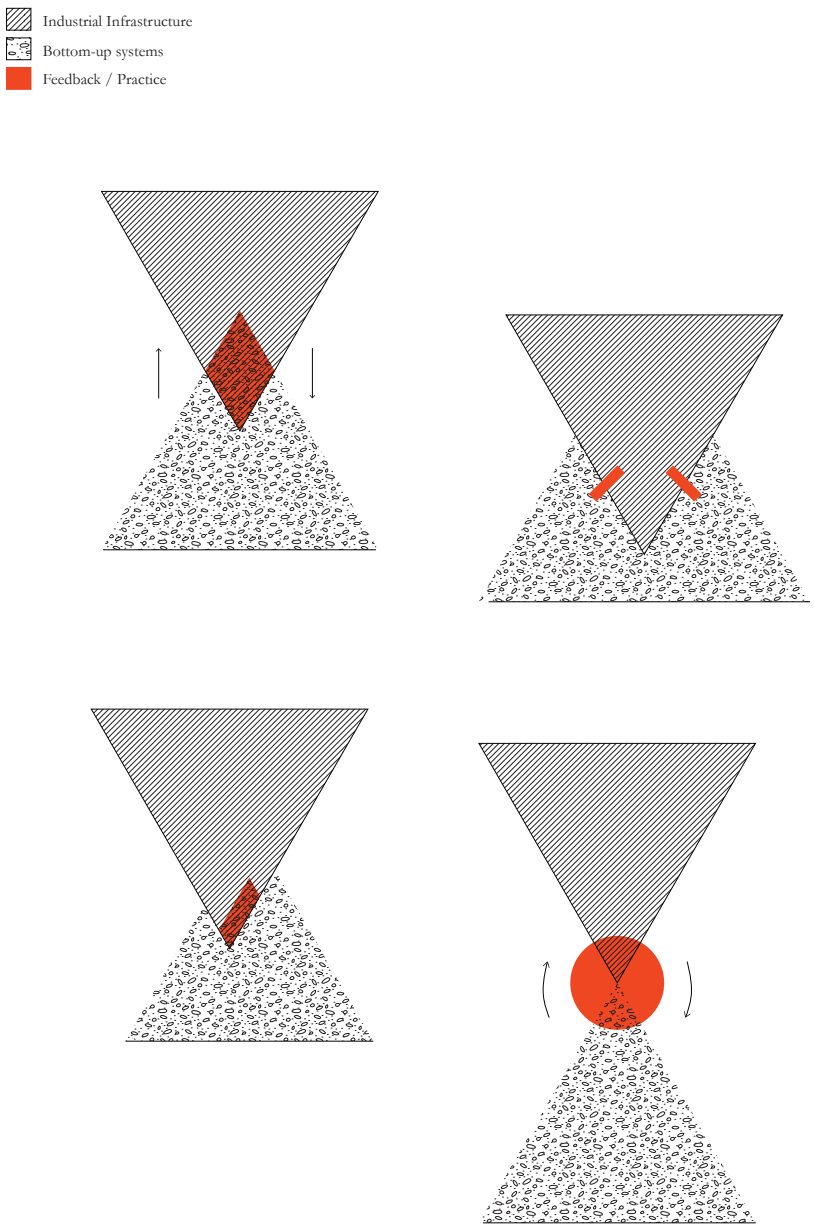
Although it is helpful to comprehend certain dynamics, the dialectical opposition between top-down design and bottom-up innovation might not be sufficient to enable and curate change within the current infrastructural regime without a 'practice' and 'material force' to move these facts and alternatives toward a new direction.

As Herbert Marcuse argues (1991), such dialectical opposition

> Is not refuted but it cannot offer the remedy. It cannot be positive. To be sure, the dialectical concept, in comprehending the given fact, transcends the given facts. This is the very token of its truth. It defines the historical possibilities, even necessities; but their realization can only be in the practice which responds to the theory, and, at present, the practice gives no such response. (253)

A possible way to break with this duality is to leverage industrial infrastructures towards more contextualized and adaptive configurations by opening them up and making them more receptive and supportive to bottom-up and social innovations. For instance, in their book 'Thinking in Systems' Meadow and Wright (2008, 157) suggest how one of the leverage points to intervene in a system is to enable new feedback loops and provide access to information to elements in the systems that didn't have it before. Through this 'transvalutation' of values (Nietzsche 1976) industrial systems could be opened to a diversity of interpretations and needs, allowing for new cross-fertilizations. This would provide a possible strategy to repurpose infrastructures on the basis of what is desirable locally and not exclusively as a product of technical and economical will. But what could a 'practice' to guide and curate this process look like?

The creation of local resilient systems and distributed economies does not mean it is an attempt to render industrial infrastructures more inclusive or to 'industrialize', socially and locally sustainable solutions (cf. Morelli 2007). In other



Making industrial infrastructures permeable and supportive to bottom-up innovation

words, "complex, nonlinear systems cannot be modeled by linking together a fragmented collection of linear models" (Fiksel 2003). Compared to industrial systems, distributed ones involve a decentralized division of physical components, ownership and responsibility, overseeing a more cyclic movement of resources that are not compatible with the present infrastructural arrangements, their hierarchical structures and internal innovation practices (Biggs, Ryan and Wiseman 2010).

If prevalent top-down processes for developing infrastructures, based on policymaking and standardization criteria, are unable to provide the contextual sensitivity and local flexibility required to address postindustrial needs, likewise, traditional industrial design practices appear to be equally ill equipped. Considering its heterogeneity, the design of this new type of infrastructure will need to include a number of stakeholders that extends the traditional client-designer-user relationships. To deal with the scale and complexity of such a system, a new systemic sensitivity is necessary and an ability to shift between scales, communities, interfaces and networks that prevalent 'industrial' planning and development approaches seem to lack (cf. Jones 1992).

A new practice

Design activities have been traditionally located at the front-end of existing infrastructures, aiming at the basic understanding of existing configurations as a starting point for design and the definition of new product and services. Such processes however, run the risk today of being insufficient to rebalance power relations and to responsibly guide the introductions of new networked systems and technologies. Contemporary issues do not only concern the accessibility and usability of devices and services by particular communities of users, but also include how these designs travel and are appropriated in different contexts. These situations call for a reflection upon the ability of prevalent design practices to question and anticipate the consequences of the designers' actions and to critically address the influence that pre-existing socio-technical configurations might exert on the scope of design (Winner 1989 19-29).

Within today's increasingly digitized, liberalized and deregulated global economies (Graham and Marvin 2001), dominant problem-solving practices, user-centered and usability criteria are insufficient to responsibly guide the introduction of new solutions. On the contrary, they continuously seem to generate and replicate

controversies and forms of discrimination and violence towards the society and the environment, but at a scale and through manifestations we cannot fully relate to or anticipate anymore. The pervasive diffusion and application of information and communication technologies (ICT) in any sphere of human life, alter establish relationship between use and location, interface and infrastructure (Mitchell 2003). As a consequence, the impact of design decisions now extends beyond expected uses and users, across locations and communities of practice.

These conditions amplify issues related to the effects of new devices and technologies on society (cf. Verbeek 2011) and exacerbate controversies between communities and the conduct of private corporations (Easterling 2014). The private infrastructures are what define what can or cannot be designed today, as well as the possibilities for citizens to equally access services and resources. These actors, despite the public implications of their activities, deliberately subtract their operations from the public scrutiny, limiting the democratic right and ability of citizens to actively participate in decision making regarding matters that concern their lives (cf. Dewey 1954).

Participatory approaches were originally developed as a way to rebalance power relations by assigning more control to end-users in the definition of features and uses of new technical solutions (Bjerknes, Ehn and Kyng 1987; Ehn 1988). Despite their ability to guide, the reconfiguration of systems towards more inclusive and democratic forms, these might not be properly equipped for this purpose anymore (Ehn 2008). The context in which designers are required to operate has a higher level of complexity and inequities in the decision making process compared to when these practices where initially conceived. Moreover, participatory approaches still largely focus their activities at the front-end of existing infrastructures and in 'solving problems' for specific groups. These 'industrial traits' might reduce the ability of these practices to address present controversies by means of limiting their ability to question and affect change within the settings that actually determine the problems they are trying to address.

What appears to be problematic is that we are designing automated and interactive systems and service-oriented business models with the same 'problem solving mindset' we used to design elementary electronics and early computer interfaces in the dawning age of the consumer society. New IT applications and design configurations are developed on top of existing industrial networks, without questioning their foundations, through design practices largely developed to 'conceal the mechanical arrogance' of their electronic components (cf. Branzi

1988). Methods and aesthetics developed to facilitate accessibility, usability and appeal of new technologies and that still persist despite the large socio-technical transformations that characterized the shift from a manufacturing to a service and information economy (Tonkinwise 2011).

As Nelson and Stolterman (2003) argue:

> The focus on problems, whether wicked or tame, as the primary justifiable trigger for taking action in human affairs has limited our ability to frame change as an outcome of intention and purpose. It means that wise action, or wisdom, is starved of its potential (. . .) Wisdom—specifically what we call design wisdom—is a much richer concept than problem solving, because it shifts one's thoughts from focusing only on avoiding undesirable states, to focusing on intentional actions that lead to states of reality which are desirable and appropriate. (17)

In the current state, however, design seems more confirming and conforming to the status quo of industrial capitalism, subjugating its service to sustaining the needs of its present infrastructures and economies, rather producing preferable solutions.

As the design historian Clive Dilnot (2015) notices: "Design after 1945 becomes, increasingly about now. Its temporal view shrinks with that of culture, to the point where, by the turn of this century, it participates only in now and can therefore only endlessly repeat without truly advancing in terms of understanding what is doing" (154). The purpose of design, planning and policy has become that of incrementally add-on existing structures, patching flaws and fixing mistakes that current planning and developing technology keep reproducing. It repeatedly makes the wrong things 'better' in a "continual accumulation of the instantly new that supersede what has been" (Dilnot 2015, 153) in the sequencing of fashions and technologies — without questioning why or what supporting this mechanism implies. The future is, as Bruno Latour (2010) describes in his 'Compositionist Manifesto', generated "looking backward while proceeding forward" (485), according to criteria and within the limit of a present that do not fit with the environmental, economic and social crises of our times, and forcing us on a fixed trajectory.

As the design theorist Tony Fry summarizes, what is emerging, is the need of a 're-directive' practice more aware of what design does and how; the production

systems it supports, what it creates and it destroys (Fry 2009, 193). 'Re-direction' according to Fry "implies the restructuring of *habitus* by design" (46-47), and the research and development of new practices and tactics to initiate and guide the transition of existing industrial systems toward more 'sustain-able' configurations. This entails the development of a new design consciousness able to break with the unsustainability of the past and re-direct the design action towards the production of a 'common good' and 'futures' able to ensure social progress.

The term 'transition' here refers to the recognition that complex postindustrial problems cannot be addressed internally by single companies or by communities alone, but requires systemic transformations (Burns et al. 2006). To achieve this purpose requires designers to shift from existing means and modes of 'industrial' design to the exploration of 'how to' configure qualitatively different value systems. This means not only to conceive and implement alternative forms of production better able to address present needs, but also to provide these alternative ways of thinking and doing design with the proper foundations to prosper (Fry 2009). That is, to experiment and articulate ways to enable and curate change in the networks of industrial infrastructures within which design operates and that inevitably influence and constrain, with their agencies, the scope of its actions.

Shifting the attention

As designers we usually tend to avoid infrastructures, considering them something too complex to deal with and outside our sphere of influence, preferring instead to work at their fringes or within their gaps. Throughout history, however, designers have from time to time engaged with infrastructural matters, advancing their practice to address systemic issues of production, sustainability, social inclusion and innovation from the bottom up. Ideas and reflections about the co-evolution of industrial infrastructures and society have not only been part of the commercial success of design, but have also been the site of criticism and experimentation in anticipation of broader social and infrastructural changes (cf. Thackara 1988).

This critical attitude to infrastructure is now becoming a central part of a new set of material inquiries, articulating and experimenting with ways to deal with the heterogeneity of a postindustrial context. Postindustrial practices, attentive to diversity and plurality of interpretations, where design forms and artifacts, are

more openly used as the means to critically question and articulate issues behind design and technology, according to which futures they support or hinder, rather than to purely solve problems. These expanding practices address issues in areas such as aesthetics (cf. Tonkinwise 2011), definitions of use (cf. Redström 2008), politics of technology (cf. DiSalvo 2012; Dunne and Raby 2013), social issues and public controversies (cf. Ehn, Nilsson and Topgaard 2014). When thinking about what is now required of design in meeting today's societal needs and advance our discipline however, what seems to be still missing is a competence with the "dark and invisible matter" (Hill 2012) of industrial infrastructures.

Despite all the important theoretical and methodological advancements toward this direction, design activities are still mostly relegated at the front-end of infrastructures and their interfaces. New services, IT applications and research activities are still focused more on 'enlightening' the unknown —the informally and spontaneously arranged— making it accountable and formalizable into problems and end-results. This is equitable with a process of continuous 'enframing' of the world (cf. Heidegger 1977), where design production and knowledge is produced exclusively at the fringes of the existing system and its network arrangements. The logics, structures and purposes of the underlying networks of infrastructures are rarely critically addressed; standards, protocols and practices, products and outcomes of the design decisions of the past, that now frame our design space and condition our ability to re-configure it.

In order to learn how to possibly address postindustrial issues and understand how to responsibly give new design and technologies a meaningful place in people's lives, the designers' attention needs to shift, from incrementally designing new systems of product and services on the top of existing networks, to infrastructures and their foundations. If, as Cross (2001) argues, the designers' knowledge is of and about the creation and maintenance of the 'artificial world', what still remains uncovered is the 'human-made world' of industrial infrastructures: structures, standards, protocols developed along the course of history and that today define what can and cannot be designed (Dilnot 2015).

This historical interpretation of infrastructures as the product of the sum of artificially created systems and rules is useful since it makes accustomed work, social practices, hierarchies and habits 'questionable', thus allowing us to escape the lore notion and understanding of these systems as a static and immovable foundation of any economic activity removed of any agency or intentionality. On the contrary, infrastructure actively shapes society through presence and

mediation (Easterling 2014; Latour 2005). Infrastructures are not only the result of inventions, design and the influence of relevant social groups, but are also the product of a co-evolution process where human and non-human actors act as equal forces in driving development (Bijker et al. 2012; Hughes 1987).

This social-construction implies interpreting infrastructures not only as 'instruments' or 'devices' but also as a mean of understanding present socio-technical arrangements; the matter through which to explore and reveal possibilities for reconfiguration of the artificial and the setting into being of qualitatively different modes of becoming. As Dilnot argues, "ethically, this is the exploration of 'artefacture' not only as an act of 'doing' but the agency of attuning complex relations between subjects, artifice and the world/earth. It is also the work through which perhaps a humane future can be brought into being" (Dilnot 2015, 176). But how can we explore and re-design something whose scale and complexity we can barely relate to, and whose functionalities and operations are largely inaccessible and privately kept invisible to the most of us?

User-led innovation processes require transparency — a transparency that existing infrastructures do not typically have. On the contrary, infrastructures are often only accessible and perceivable through a predetermined set of points of interaction at their front-end. As the term suggests, *infra*-structures operate beneath the surface of human interaction and therefore are not readily available for inspection or design. Some of their networks are partially visible and obvious, such as transportation, telecommunications, energy and water supply, and are accessible though interfaces such as the power outlet in the wall or the postbox on the street and the front desk of a bank. Other infrastructures are instead more subtle and intangible, such as trade policies, norms, technical regulations, codes and algorithms that run in the background of society, concealed behind software, devices and institutions that require them for their operation (cf. Borgmann 1987; Easterling 2014).

Despite these signs of presence, back-end functionalities, scale and purposes according to which these networks and protocols operate and interact remain obscure to most non-experts. Taken for granted and naturalized in the background of our life routines (Star and Rohleder 1996); protected by security systems and ruled by their own languages and technical protocols (Easterling 2014); infrastructures and services make it difficult to question the logics and interests behind their dynamics. In particular they make it impossible to entirely perceive and understand the effects of the collective agency that this ever-

growing and black-boxed web of interrelated networks of companies and their facilities has in our communities. Thus, in this inquiry into how to enable and curate the transition of our network of industrial infrastructures towards more sustainable, democratized and citizen-centered configurations, this is where we shall begin: to explore possible ways to give infrastructures a presence, unfolding the complexity and logics of their socio-technical arrangements, and make them accessible for design inquiry.

Towards a design practice for transtructures

'Transtructures' is a term coined to identify a new kind of locally adaptive infrastructure, designed to support distributed manufacturing and service economies, and promote a more democratic access to technologies and resources. The purpose of this concept is to provide a possible model to guide the transition of industrial infrastructures toward more locally adaptive and citizen-centered forms and functions. As such, it offers a 'programmatic frame', and a possible direction in which to research and explore, through a series of design experiments, what a practice to responsibly reconfigure and attune these systems to contextual needs might look like (Binder and Redström 2006; Redström 2011).

Trans- involves the 'linking across and through' industrial networks but also their transformation and ability to contingently adapt to local situations and needs, 'transparently' (Star and Rohleder 1996) supporting different people and practices. Diversely from Product Service Systems (Ceschin 2013) and collaborative services (Jegou and Manzini 2008) with which it shares many features, Transtructures are not about fulfilling specific demands. They do not exclusively serve one purpose or a community, but multiple ones supporting different business models and activities at the same time. Their platform and 'code' are flexible, replicable and adjustable in different contexts without the need of being re-invented every time (cf. Hunt 2005). Their design is therefore not really achievable through 'industrial' design approaches, which were developed to address the needs of definable communities of users through homogenous practice styles (Tonkinwise 2001; Redström 2006).

The basic assumption behind the notion of transtructures is that many of the complex issues concerning privacy, security, equality, labor and economic stagnation that today characterize industrialized countries[2] appear to be intimately connected to a set of complex and interrelated processes that characterize their current infrastructural development: such as the centralization of value production around a limited number of global nodes; the concentration of infrastruc-

2 When discussing topics such as economy and regional development, in my analysis and interpretation of globalization phenomena, I maintain the point of view of a European designer working mainly within a European context.

tural assets in the hands of the few members of society, their privatization and the concealment of their operations (Easterling 2014; Fuchs 2010; Graham and Marvin 2001; Piketty 2014; Vitali, Glattfelder and Battiston 2011). If these are the sources of the many limitations to social and economical progress, then exploring ways of bringing back the operations of infrastructural networks to the more perceptible and relatable scale of the community —articulating ways to retain value, knowledge, skills and technologies required for their operations under the control of the communities that use them— could perhaps be a mean to mitigate some of the effects of these forces. Transtructures would therefore work as a catalyst between industrial rationales and local communities, allowing tailored access to services and infrastructures for actors that are currently excluded by prevalent development processes.

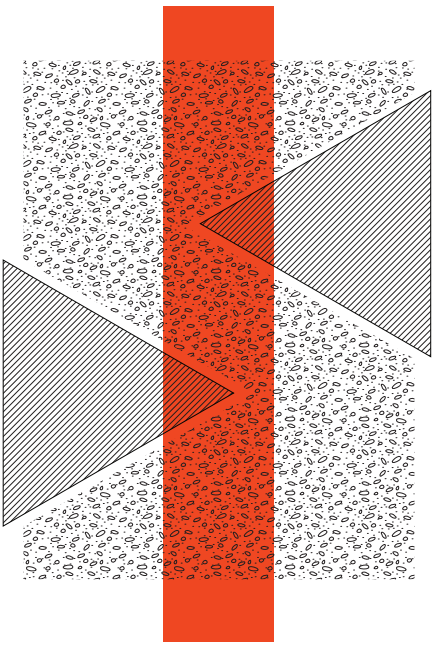
Critiques and reflection about the socio-geographical implications of industrial organization, the technological meditation of its networks, and how these need to be modeled towards more human-centered configuration to better serve society, have been part of the design and political discourse for a long time. For instance, the architect and designer Ettore Sottsass in the late 50s expressed concerns about the mediation of computational devices and the new design awareness this implied. As he noticed after the design of a large mainframe computer for Olivetti, the design of these artifacts is not limited to the provision of functionalities and end-results.

As Sotssass (as quoted in Sparke 1982) describes:

> It was immediately obvious in the first years in which I worked on the ELEA that in the design of certain gigantic instruments, as electronic machines were then, one ends up immediately designing the working environment; that is, one ends up conditioning the man who is working, not only his direct physical relationship with the instrument, but also his very much larger and more penetrating relationship with the whole act of work (. . .) conditionings, the liberty, the destruction, exhaustion and death. (63)

Similarly but on a larger scale, the industrial entrepreneur Adriano Olivetti — owner of one of the first IT companies of history and producer of ELEA— in his political essay on state organization "the Political Order of the Communities" (1946), suggested that 'inability of the liberal state to face the cyclical crises and the problem of technological unemployment' is mainly due to the organization of production activities and their planning. As an alternative solution Olivetti

Industrial Infrastructure
Bottom-up systems
Transtructure



'Linking across and through' industrial and local systems.

proposed configurations based on 'communities' as a means to address these problems. These communities rested upon distributed units of a limited number of inhabitant to oppose the 'chaos and privileges' of cities around which capitalism and industry organized their functions[3] (Olivetti 1946). Community is for Olivetti, not 'on a human scale' but is the 'measure of humanity' is the space in which a citizens can fully express their 'relational' life: "A system is balanced and efficient only when the men in charge of certain tasks can carry them out through direct contacts" (27-28). In particular it is, first of all 'a space', a portion of the land where people can dwell and live together 'composing conflicts' in virtue of a common 'moral and material' interest.

Retrieving some of these modernist ideals of public good and criticism towards centralized forms of industrial organization that characterized Olivetti's thoughts, and Sotssass' awareness of about the new sensitivity required to model IT and interactive systems, transtructures can offer a possible lens to look through at the design space and explore possibilities to re-configure industrial networks toward more inclusive and citizens-centered configurations. By offering a vision of an alternative future that better meets contextual needs transtructures antagonize prevalent infrastructural configurations, exposing people and communities to the limits of these systems (cf. DiSalvo 2012). However, producing utopian visions might not be sufficient to ensure a transition towards preferred conditions and these ideas could be still appropriated and implemented in more traditional top-down or bottom-up ways.

To become a 'strategy' transtructural scenarios require the definition of a practice able to inform how to possibly enable and curate change within the set of existing infrastructures and practices that define the design space in which they will operate (Fry 2009, 151-155). New and multidisciplinary approaches, open to diversity and plurality of interpretations and able to work across different networks, locations, scales and communities of practice need to be explored to understand what these new types of configurations can look like and how to

3 Translated and summarized from Italian: "L'idea fondamentale della nuova società è di creare un comune interesse morale e materiale fra gli uomini che svolgono la loro vita sociale ed economica in un conveniente spazio geografico determinato dalla natura o dalla storia. La Comunità è intesa a sopprimere gli evidenti contrasti e conflitti che nell'attuale organizzazione economica normalmente sorgono e si sviluppano fra l'agricoltura, le industrie e l'artigianato di una determinata zona ove gli uomini sono costretti a condurre una vita economica e sociale frazionata e priva di elementi di solidarietà "La "misura umana" di una Comunità è definita dalla limitata possibilità che è a disposizione di ogni persona per dei contatti sociali. Un organismo è armonico ed efficiente soltanto quando gli uomini preposti a determinati compiti possono esplicarli mediante contatti diretti."(Olivetti 1946, 27-28)

safely accommodate them. Thus, the aim of this inquiry is not to prove the effectiveness of transtructures as a 'solution' —that is the design of a new kind of infrastructure— but to start to investigate and prototype what a *'transtructuring'* practice to initiate their configuration and properly support their introduction might be; the kind of processes and competences it needs to include; the variety of forms it can produce and the type of knowledge it might afford; probing the existence, or not, of a possible design space where future development can take place (cf. Redström 2011).

Background and context

Information and automation technologies embed great flexibility for different types of applications and more horizontal configurations. However, they also conceal the risk to preserve hierarchies and to produce new types of coercions and inequities (cf. Feenberg 1990). Rebound effects that we, as designers, must learn how to anticipate taking responsibility for our actions. When the first mobile phones were released in to the market, for instance, companies and designers focused their attention on functionalities and usability, but no one thought these devices could become one of the main responsible for lethal car accidents (Saifuzzaman et al. 2015). This is because technologies are "active" (Latour 1992) in the sense that with their design and organization they convey certain types of information and not other. Thus influencing human interaction by enhancing, or inhibiting certain human behaviors. At the same time people interpret and appropriate technologies according to their own rationale, situations and situated needs, opening them up for unexpected uses and innovations, but also for potential misuses (Ihde 1993).

This design awareness is particularly relevant today. The increasing complexity and infrastructural nature of interactive systems and their ubiquity requires designers and engineers to explore new ways to properly and ethically attune new devices and technologies to their context of use. The introduction of a 'smart' mobility system operated by autonomous vehicles for instance might require a deep understanding of the site where it will be implemented to avoid possible accidents and costs associated with wrong evaluations of its agency in the real world. Possible risks and consequences will need to be somehow explored and acknowledged before new designs are actually released and not just mitigated in retrospective regret after something happens. Similarly, forms and functions of vehicles, interfaces and software applications that run this system cannot be

replicable and identical everywhere —as it used to be with scale manufacturing— but they will need to adapt according to the different social contexts and environmental conditions. After all, a southern European city will likely provide a very different setting, cultural attitudes and needs compared to a Northern American suburb.

Technological mediation does not only apply to physical networks and artifacts but to any form of arrangement and organization (Easterling 2014). For instance, although their effects and social implications are more subtle and harder to relate to, digital networks also have agency (Easterling 2012). Through their interfaces, devices, mobile applications, web-browsers and social media conveniently provide access to services and commodities. What is less visible however is the disposition of the companies that manage these services and the data they produce; the use they make of them and the practices they support (Boyd and Crawford 2012; Pasquale 2015). These activities raise several concerns about neutrality and how in the contexts of the contemporary deregulated global economy they appear to influence local economies and the functioning of our primary institutions. Infrastructures, designed in completely different historical contexts and to cope with very different problems, that today appear unable to keep up with the rhythm at which controversies produced by private initiatives continue to emerge, undermining the labor and civic rights that mass society painfully achieved through the course of history.

New services and devices might solve problems for certain communities or categories of people but at the same time their use, operation and the behaviors they support might represent concerns for others. As such, designers are ethically and professionally required to acknowledge how to address these conflicts. This is not only a matter of identifying preferable alternatives but also of learning 'how' to responsibly adjust new systems and uses within the installed base of industrial infrastructures and practices that currently support our societies. This means to acknowledge the presence and agency of other networks and the changes required on their behalf to provide new designs with the proper foundations to fully develop with; but also the environmental factors and cultural needs of the places where new systems will be introduced to provide them a meaningful role in people's lives.

To address this complexity requires designers to engage with the politics of infrastructural configurations, establishing a new type of relationship between their work and the contexts of use of their future solutions. As the philosopher of

technology Peter-Paul Verbeek argues (2006) this can be achieved by 'augmenting' the design process opening it up to the unpredictability of the field and its variety and diversity of actors and interpretations. This has the potential to be a process through which designers can identify features, uses and qualities of their designs 'through use' (Redström 2008), while continuously feeding back their own understanding of what 'ought to be designed' with the situated contingencies that characterize their site of use. According to Verbeek in this way, design becomes an instrument to 'democratically organize technology' (Verbeek 2006, 372-373).

This interpretation of design as a mean to enable democratic participation has two consequences for this present research and in the configuration of transtructures. Firstly, there is a need to research what activities and materials are necessary to engage 'citizens' in the exploration of infrastructural issues and the evaluation of future configurations (cf. DiSalvo 2009). This means giving an opportunity to plurality of very diverse individuals, with different opinions, values and interpretations —as opposed to the commonalities of 'users'— to participate in the direction and the decision making process about technology and, since power is exerted through infrastructures (Easterling 2014), in the political systems. This entails the development of methods to enable people to 'actively' and therefore democratically access, relate and discuss infrastructural and technological matters and their implications, allowing them to experience and judge the impacts present and future configurations have, or might have, on their lives (cf. Dewey 1954).

Second, there is a need to develop tactics and rhetorics to educate and guide industries in the transition process towards systems and market configurations that are radically different from how they habitually manage and develop their networks. Large corporations are usually reluctant to change, a condition that is quite understandable when having the responsibility to maintain and sustain through their work thousands of people and businesses. Nevertheless, "questions about the instability of the present under the influence of decisions planned in the past and coming about in the future" (cf. Jones 1992, 33) are a source of anguish for many large corporate boards. The opening-up of radically different possibilities for more flexible manufacturing and service oriented business models are today exposing the inappropriateness of hierarchical industrial architectures and their models to fit within the new postindustrial landscape and its social needs (Hunt 2005; Margolin 2002).

The commitment to previous investments and established ways of organizing production and supply of services and goods will work in the short term, but wont' be able to provide a long-term strategy for businesses. In the uncertainty of today's context, market driven analysis and systems optimization strategies are not able to prescribe action and do not provide any guidance in the definition of new market configurations. The problems we are facing are not addressable internally and by single companies. They are systemic and will require the reconfiguration of entire market segments and of the interactions among competing companies and service providers. More importantly, they will require the articulation of new types of relationship between private and public institutions and exploration of practices and tools to mediate between their often-conflicting needs.

Research questions and methodology

This leads us to the central methodological question of this design inquiry: what design practices could be developed to support the transition of existing industrial infrastructures towards more citizen-centered and distributed forms? And what a design process, aware of the political ambiguity of technological mediation, can be like that is neither top-down nor bottom-up to guide this transformation? To answer these questions I initiated a set of design explorations aimed at engaging publics with infrastructural issues, experimenting with methods and tactics to render existing industrial systems receptive and supportive to bottom-up innovation (cf. Di Salvo 2009).

Drawing from theory and knowledge available in the design discipline, I first drafted a possible research framework and methodology to provide me with an entry point in the field of infrastructures. Relational theories were used to define a possible practice and approach to large socio-technical systems and their dynamic formations, as well as to interpret and evaluate the result of my design activities. In particular, Actor Network Theory (Latour 2005) offered a lens to look at infrastructural networks as the products of human and non-human agencies and to identify strategies to visualize and unpack their interlaced structures, contingent meanings and power relations, through the practices they support (Bowker and Star 2001). A second fundamental methodological perspective to approach infrastructures as a subject of design is the analysis of infrastructural development processes offered by urban studies scholars Stephen Graham and Simon Marvin.

In their seminal book 'Splintering Urbanism' (2001), Graham and Marvin argue that infrastructures need to be understood in light of the privatization and deregulation processes of former public utilities and the politics of inclusion and exclusion they produce [4]. These are layered and complex phenomena that are difficult to articulate and distill into single solvable problems. If their description and analysis can be broad and complex however, according to Graham and Marvin, the effects and presence of these forces always manifest themselves locally and in tangible ways. Thus, they can be understood only through site-specific investigations (Graham and Marvin 2001), through their most basic elements and de-theorization and from the ground up (Sassen 2014).

To this purpose, art-based research practices give us a situated and an embodied ability to navigate heterogeneity and generate knowledge. As the Architect and Design Methodology professor Chatarina Dyrssen (2010) describes it, physical models, fictions and visualization, allow designers to contextualize 'heterotopic' conditions[5] and navigate the complexity of the context. Starting off with a precise action or a question, or an observation, the researcher gradually constructs or composes her/his own research set up alongside the prototyping activities. Through a continuous dialogue between the materials and the situation — making and undo— (cf. Schön 1995) new relationships, agencies, meanings and understandings emerge, allowing the identification of possible directions and preferable solutions. Thus, this process "breaks up the traditional linear narrative of the research process, as starting with a problem, moving through analysis and theory, applying theory back to empirical studies, and finally arriving at concluding solutions. Instead, it promotes constant, quick shifts between innovation and analysis. Associative, lateral thinking is combined with logic/deductive reasoning and theoretical reflection" (Dyrssen 2010).

4 By the end of the 60s, the social and collective premises of public interests and modernist ideals that guided industrial development since the end of the Second World War, slowly gave way to private corporate initiatives, radically changing the disposition according to which these systems were initially conceived. With the maturity of markets and their progressive globalization, the integrated planning and centralized design of industrial and national monopolies started to be perceived as unwieldy, inefficient and unable to catch up with the needs of markets and society. High capital-intensive industries, public infrastructures such as gas and electricity, railways, telecommunications, water, started to be segmented and privatized. From this moment, the main purpose of these networks is not to provide access to services and commodities equally to everybody anymore, but to make a profit (Graham and Marvin 2001). The consequence of this deregulation process is, for instance, the differences in access to services between cities and sparsely populated areas with low density and, therefore, commercial value. Another effect of the increased number of actors and their conflicting interests is the higher complexity in finding and organize solutions on a systemic level to urban and regional issues (cf. Dablanc 2007).

5 Spaces and situations characterized by multiplicity and heterogeneity of layers meanings, actors, interpretations and relations to other contexts (cf. Foucault and Miskowiec 1986).

Following these theoretical and methodological perspectives, I therefore outlined a possible research program (Redström 2011) within which to explore through a set of design experiments, how, agencies and logics of present and future infrastructures can be made 'real' in the sense of becoming present and available as material for design and participation. The basic structure and premise of this program are that, since the primary obstacles to initiate the transformation of industrial infrastructures are the inaccessibility and invisibility of their back-end logics and operations, this is where we need to start – to materialize and make visible that which is otherwise hidden. Then, after materialization, new configurations can be prototyped out of this material and collaboratively investigated through design performances, concept rehearsals and prototyping sessions in the field. Once carried out, the outcomes of these explorations can be finally evaluated in relation to the original motivations and intent of the program, making them available for further questioning and interpretation (Binder and Redström 2006).

Fields of inquiry and subject of my exploration were the areas of logistic and broadband telecommunications. The decision to focus on the design of these specific networks is grounded in the recognition of the strategic importance that both the logistic infrastructures and ICT play, along the course of history in shaping current industrial configurations, markets, economic activities and work practices. For instance, the telegraph and the railway contributed to defined structures and practice of companies in early industrialization, providing the essential organization elements for modern businesses (Chandler 1993): top down pyramidal organization, rationally designed to optimize the cost through a rational organization of labor activities and coordination of supply and distribution. Similarly, the diffusion of the Internet in the early 90s and its decentralized networks largely influenced the business models of today's dominant IT companies and the organization and supply chains of businesses and governments that rely on it for their operations (Turner 2010, 175). Strategic relevance and reliance on each other makes it plausible to think these will also be the first systems that will need to change to enable and support new distributed economies.

For these reasons, understanding the organization of material and information flows of these qualitatively different systems can provide a valuable case study and field of application for approaching and relating to other industrial infrastructures and the geographies and politics of inclusion and exclusion they produce. In particular, last-mile distribution and mobile meta-data market issues addressed in this thesis offer clear examples of the inequalities and discrimination

that market-driven development practices exert in excluding communities from accessing services and the means of value production. Coercions and tensions that are already partially perceivable locally therefore offer a good test-bed and area of application to explore, prototype and evaluate a re-directive practice and its efficacy (cf. Graham and Marvin 2001, 382).

Thesis structure and contributions

This dissertation is constituted of two main parts. Section I, *"Design and Infrastructures"* will provide reasons and evidence in support of the claims stated in this introduction. The chapters of Section I are meant to provide designers with the basic background knowledge for understanding the reasons and motivations behind this research and definition of transtructures as a possible vision and solution to postindustrial issues. Knowledge that is often excluded from design curricula over more practice based design education and programs but I think is becoming now necessary for the education of responsible and empathetic future designers. In particular, I will here provide an historical account from a design perspective of the co-evolution of design and infrastructures and the relationships between top-down and bottom-up innovation. Issues and dichotomies that characterize our postindustrial society will be here more deeply articulated, highlighting the advantages and limitations of established industrial design practices by addressing them. Finally, new postindustrial approaches and ways of using design will be introduced in order to provide the necessary foundations for the definition of a possible practice to initiate and curate the transition of industrial infrastructures.

In Section II *"Transtructures"*, I illustrate the empirical exploration of how this vision can be achieved. I will here first introduce the methodology adopted in my design inquiry. A research framework based on the concepts of 'figuration' and infrastructure 'as co-design material' was developed and tested through a set of design experiments in revealing and materializing infra-structures —what is usually concealed and hidden beneath the surface of human interactions— as a way to make them present and available for inspection and as materials for design. Here, details and insights of these experiments and their processes will be presented and discussed. The cases expose the rich opportunities behind the use of design expressions and forms as the means to inquire into the artificial space of industrial infrastructures and to collaboratively explore possibilities for their transformation. The purpose of these examples is to start exploring what the

activities and interventions of a new redirective and transitional design practice for postindustrial infrastructures might make use of.

These experiments, with the elements and approaches of this new 'transstructuring' practice, are intended to both provide a sense of direction for exploring alternative infrastructural arrangements and a set of tools for learning more about how to configure them. On one hand, design materials and forms are here employed to 'hack' and fictionally 'break-down' infrastructures, making them accessible and tangible. These critical design interventions are used to produce the materials and arguments required, enabling re-direction, overcoming initial resistances and rebalancing power relations (cf. Fry 2009). On the other hand, design materials are the medium through which designers can explore how to possibly reconfigure interactions across networks and actors already in place, attuning them towards this model (cf. Burns et al. 2006). Transtructural scenarios are, in fact, not static, but constantly readdressed according to contextual needs and contingencies. This is done through an open and situated prototyping process aimed at understanding how these transformation processes could unfold, anticipating opportunities and controversies that present and futures configurations might conceal.

The backdrop of this present work is largely within participatory design and the development of methods and tools to guide the design and modeling of systems and infrastructures suitable for the contexts of today's liberalized, digitized and global economies. What emerges from this inquiry is a new mediating role for designers, between the interests of networks operators and the democratic rights of citizens to participate in the decision making of what concern their living and dwelling. An ambiguous role between the activist and the collaborator, that articulates ways to meet their conflicting needs. The image of the practitioner that results, is one who has her own political agenda, perspectives and action plans about what kinds of transformations are required and in which directions. But at the same time, she constantly opens up her work to others for critique and feedback, making her actions and process explicit, in a continuous and transparent dialogue between materials, people and the context.

The contribution of this inquiry to design discipline and the evolution of its practices is twofold. The first contribution is the conceptualization of transstructures along with the historical and contemporary backdrop that forms its basis: a 'vision' that contributes to affirm the role of design as an embodied and situated practice of inquiry, re-affirming the intentional configurative role

of the designer in the identification and envisioning of qualitatively preferable solutions. The second contribution concerns design methodology and is an experimental inquiry into what it might take to realize such a vision, by looking at aspects of processes, materials and politics that such design practice entails. Through design, entangled social, economical and technical post-industrial issues that are otherwise difficult to articulate become relatable, providing experts and designers with the necessary materials for dialogue, to better understand and unpack present matters of concern and collectively explore the possibilities for change.

I. INFRASTRUCTURES AND DESIGN

Infrastructures evolved together with society through a series of complex economic, political and social negotiations, technology-push and demand-pull factors. When changes occurred and new demands emerged in society, infrastructures needed to co-evolve[6] along with them in order to provide people and companies with the right foundations and tools to keep thriving. Similarly, design practices needed to meet the changing socio-technical requirements. Throughout history designers constantly evolved their methods and tools. They did so, not only at the interface level but also to imagine and critically explore new types of systems and infrastructures, progressively engaging with issues of scale, production, accessibility and participation. Tracing back how the co-evolution of design, technical systems and infrastructures took place can help to better understand how certain qualities and logics of the paradigm we operate within actually influence how we think about and do design.

This first section will provide an account of the relationship between infrastructures and designs, providing the necessary background to better interpret today's postindustrial issues and some of the theoretical and methodological questions it opens up for the design discipline. This is not meant to be exhaustive. The size and complexity that this operation would entail exceeds one dissertation that has other intentions, making it obviously prohibitive[7]. Therefore, I will here use selected design examples as a backdrop to articulate and support arguments about the need to rethink the way we design and model interactive system and infrastructures.

What emerges from this overview is that despite all the socio-technical transformations and varieties of designs produced by either top-down and bottom-up efforts only a few things seem to remain constant in time. One is the role designers play in the definition of new infrastructures and market organizations in the anticipation of broader social and infrastructural changes. A second is that design practices, as much as infrastructures, are not only the static outcomes of invention but also the products of the active and reciprocal influence and interaction between technical systems, society and its relevant social groups (Bijker et. al 2012); Finally, despite the important methodological and technological advancements, there is still a certain 'industrial' continuity in the way design

6 For a detailed chronological account of these transformations see T.P. Hughes' work on "The evolution of large technical systems" (1987) and Graham and Marvin in "Splintering Urbanism" (2001).

7 Especially for a designer trained to make furniture and appliances, and therefore lacking the background experience, argumentative skills and sensitivity that more traditionally analytical disciplines in the fields of humanities, science and technologies studies, for instance, have.

practices and technology are conceived. This persistence today appears to be limiting our ability to address postindustrial controversies.

The section is structured as follow. The first chapter provides a historical account of some of the work produced by architects, designers, and technologists from the second half of the 20th century. These examples will allow me to trace back the origin of some popular interpretations of systems, technology and bottom-up innovation and to articulate some their issues and limits. The second chapter instead, is centered on today's postindustrial tensions. Here I will illustrate some of the consequences and rebound effects that the permanence of industrial ways of designing and the conceiving of infrastructure produce in the settings of today's pervasively connected and digital society. Topics of 'invisibility' 'disposition' and 'agency' of infrastructures will be here also introduced, setting the stage for the third chapter, where they will be more deeply theoretically addressed. Invisibility is, in fact, not only an issue of accessibility or intelligibility for the purposes of the organizational logics of infrastructural hardware and software components. Concealment is also intrinsic in a very particular way of interpreting technology and doing design around which western societies organized and developed, and that we might have to 'estrange' in order to evolve our practice and meet postindustrial needs.

From the fourth chapter, the attention will shift more toward the design practice. I will here present examples of design approaches to systems, services their interfaces and how their development can be seen as responses to industrialization and the shift towards mass production; as a means for meeting social demand for higher sustainability, social inclusion and accessibility to new technologies required at the time. Using these examples as a background, I will introduce some of the key arguments made regarding the inability of such designs to cope with contemporary challenges. Design practices to better provide the sensitivity required to operate within the today's context are already researched and investigated and will be presented in the fifth and final chapter of this background section. The theoretical stances and methodologies of these approaches constitute a foundational body of work for the definition of the transitional design practice explored in this thesis and presented in detail in the second part of this dissertation.

Between criticism and anticipation

Design did not always conform to the market rationale or to the prevalent interpretations of its practices. On the contrary, over time designers questioned the relation of their practice to society and production, exploring alternative ways of modeling systems and infrastructures according to the changing socio-technical requirements. Material inquiries and speculative works that often anticipated cultural changes and technological possibilities exposed many of the limits that prevalent infrastructural arrangements and designing practices had in addressing new social demands. Despite the different negotiations and forms they took in their transition from the original ideals and intentions to reality, these concepts and practices are in fact now largely assimilated into our present. An ambiguous role between criticism and anticipation that allowed designers to constantly advance their practices and that in many ways contributed to shape imaginaries, expectations of future markets and infrastructural configurations.

Reflections about the role of design within the 'big picture' are recurrent in history. It happened in early industrialization when new manufacturing technologies where opening completely new opportunities for society and design, as well as in the 50s when the growth of industrial production required designers to expand their methods and toolkits to face the increasing complexity of society and its technical systems. To provide the means to better interpret today's postindustrial dichotomies and political implications of technology, however, what is interesting is to look more closely at the set design debates and explorations that took place in the cultural climate of the 70s. The decade was a dense period, characterized by political tension, quickly changing global socio-economic scenarios and strong acceleration in the development and application of microelectronics in any sphere of working and private life.

This chapter will provide a chronological overview of this dynamic relationship and co-evolutions between design, society and technology. Examples from design, architecture and counterculture experiences from the late 60s up until the early 90s (where the postindustrial society has its foundations) will be presented as a way to pursue where certain interpretations of systems, technology and antithetical top-down and bottom-up modeling approaches to infrastructures come from. Notions that became popular around these years, and that despite their several flaws are still largely influential today in the way we interpret innovation

and the role of computation in the design of smart systems. These examples will allow me to expose some of the strategic limits of dialectical forms within bottom-up innovation and the reductionist risks concealed in computational models and approaches to participation. At the same time they will provide evidences of the relevant role critical and speculative practices had for development of the design discipline and the evolutions of it surrounding systems.

Industrial design practices

Designers have been operating in the realm of the critical and speculative for a long time. For instance it can be argued that craft-oriented design practices at the beginning of 20th century, based on form-function relationships, such as those of the Deutsch Werkbund and the Bauhaus, did not correspond to the reality of production and consumption of their time yet (Dilnot 2015, 154). On the contrary, they were critical of the persistence of decorative practices of their times. At the same time they were explorative of the new aesthetics and possibilities that mechanized manufacturing and scientific advancements were providing (Albers 1968; Pevsner 1936). At the beginning of western industrialization, in the beginning of 19th century, factories started to grow around cities, attracting workers from the countryside to work in their assembly lines. The unprecedented level of urbanization required the creation of the essential supporting infrastructures and services to allow a decorous and safe life in cities, from sewage to public lighting. In the frame of these new living conditions, the design and manufacturing of scale manufactured objects, furniture and appliances was necessary improve the quality of life of and fulfill the basic needs of a modernizing society. Speculative works that together with the artistic production of groups like the Futurist movement in Italy, became central for the persuasion and education of society and industry to a mechanized future and modern style of living.

In a similar way the, cultural changes and advances in the field of automation and miniaturization that started take place in the 50s required designers a higher level of awareness about the systems they had to interface with. If for Walter Gropius the system of reference for research into design and its outcomes was the 'building', this was not enough anymore. Thus, the necessity to elaborate new methodologies to work across different level of complexity and scale, attentive to society and users needs, and the economical factors of production. Articula-

tion of a new practice and approaches that are well reflected and synthesized by design elaborations of the Hochschule für Gestaltung of Ulm and its curricula in design education (Maldonado 1958; Lindinger 1990). Ulm's work in many ways anticipated future practices, providing the identity and methodological rationalization that characterized much of the more traditional areas of design that concerned the classic space of mass production in later years (Branzi 1988). Elaboration that did not hide a certain criticality towards what preceded them.

As Herbert Lindinger (1990) notices in his account of the school evolution:

> As design was now to concern itself with more complex things than chairs and lamps, the designer could no longer regard himself, within the industrial and aesthetic process in which he operated, as an artist, a superior being. He must now aim to work as part of a team, involving scientists, research departments, sales people, and technicians, in order to realize his own vision of a socially responsible shaping – Gestaltung – of the environment. (11)

With the continuous expansion of industrial systems and the definitive shift to mass production and consumption however, a further step and evolution became necessary. New objective and rational methods had to be developed to deal with the new complexity of technology and global scale of markets and society.

Top-down and bottom-up

When wicked and complex problems (Rittel and Webber 1973) such as population growth, energy crises and limited natural resources, economical downturn and growing social inequities started to emerge it became clear they could not be solved through intuitive design methods and processes conceived to deal with basic issues of usability and form and based on the common sense of the designer (cf. Meadows et al. 1972). Awareness led many designers to engage in a long lasting discussion about 'design methods' and the role of designers in society. In particular many of them started to raise questions about the limits of established problem solving approaches and the necessity to develop new objective and systematic methods to cope with issues at a broader scale and a higher degree of complexity than before (Cross 2001).

A broad number of theorists started to advocate the importance of adopting rigorous scientific, analytic and partly formalizable design methods and solutions (cf. Simon 1996). Systemic approaches, based on operational research and scientific methods to problem setting and solving, and borrowed from the beginnings of computer techniques and management theories, started to grow and be widely adopted in the development of design solutions (Cross 2001). In particular structuralist, top-down cybernetic arguments and communication theories started to be largely embraced as a way to handle the complexity of the man-made world. According to this perspective, artifacts, nature, human activities and their relationships needed to be understood as part of universal overarching mechanical systems and accountable structures managed by mathematical mechanisms of input and output feedbacks, where information and action are dissociated from meaning or judgment (Wiener 1961; Odum and Pinkerton 1955; Shannon 2001).

Emblematic of this school of thought was "Manual for Spaceship Earth" (Fuller and Snyder 1969), where Buckminster Fuller, one of the main promoter of these concepts, suggested the metaphor of planet earth as a spaceship: a closed, rational and quantifiable system with finite resources, requiring the reorganization of its management structures and new accounting systems for the maintenance of its ecosystems. Accountability that was achievable, according to this vision and belief, through computers and technological progress. This vision did not correspond to reality, the idea of human-biological systems as balanced and homeostatic mechanical models is in many ways an over simplification[8]. But nevertheless the concept of earth as a finite, closed rational system discoverable through science became, and still largely is, common knowledge.

The use of mechanical analogies to describe natural phenomena and the idea to approach complex biological, social, mechanical systems as a close set of actions and feedback loops was not only functional to the rhetoric of top-down positivist views of society and technical development. The cybernetic stance was in fact a dominant thought at the time (Bowker 1993). As such it also penetrated and highly inspired many anti-modernist exponents, architectural works and

8 Several experiments showed some of the fallacies of cybernetic perspectives in analyzing heterogenous and open systems. For instance, Van Dynes in his 'biosphere experiment' (Coleman, Swift and Mitchell 2004) unsuccessfully tried to model a complete ecosystem based on real-world data with a computer to prove how the stability of natural systems actually worked. Similarly years after their publication, predictions and models used in the popular book "The Limits of Growth" (1972), exposed many of the limitations of computer models to forecast future conditions and prescribe actions about climate. Computational models and algorithms, no matter how sophisticated, are still products of human artifice that, according to their design, might make us see certain things while concealing others (cf. Verbeeke 2011; cf. Latour 1992).

counter-movements, which started to interpret and envisioning cybernetics and technology as possible means of liberation from authority, by prototyping and envisioning new democratic and sustainable forms of organization that equally highly influence today's dominant world views.

Towards the end of the 60s the modernist stances that guided infrastructural development from the end of the Second World War and around which entire states and societies had developed and organized, suddenly appeared oppressive and insufficient to meet social needs and demands for diversity. It is in this context that many critical reflections and ideas about society and infrastructures were first conceptualized and materialized, shaping and influencing interpretations of technology and expectations about do-it-yourself and bottom-up applications that are still largely diffuse today. In particular, it is around this time that methods and systems more attentive to individual needs and sustainability are first elaborated; approaches and concepts that will largely influence the development of design methods and participatory practices in later years.

To explain these stances and the backlash against design methods we must contextualize it in to the socio-cultural climate of those years. Political tensions and the rebellion against authority nourished a debate about the subordination of society and design to market logic and industrial rationality, in relationships well expressed by some influential intellectuals of the time. As the philosopher Herbert Marcuse (Marcuse 1991) pointed out, there is an ambiguous meaning behind the process of industrial "rationalization". In a society that replicated itself through a growing set of technical systems, things and relations, quality of life standards indeed increased. But with them so did social oppression through the homogeneity of values, views and expression that this rationalization created (146). In other words, it was argued, "today domination perpetuates and extends itself not only through technology but as technology" becoming "the great legitimation of the expanding political power that which absorb all the sphere of cultures" (158). According Jean Baudrilliard's analysis and "Critique de l'Economie du Signe" (2010), artifacts have become functional in relation to this cultural oppression and flattening, as the embodiment of homologated, codified and tradable values that, through their presence and agency, mediate and alter human experiences and relations by framing them in a pure logic of consumption.

Critiques to authority, cybernetics ideas and attention to the individuals, were not only limited to the theoretical and methodological debate, but were quite

pragmatically present within the design and technology community. For instance, it is in these years that the designer Victor Papanek raises some important ethical questions about design and the sustainability of its practices. In his book "Design for the Real World" ([1971] 2011), Papanek argues for the necessity of opening up and democratizing the design process. According to his view prevalent rational, top down and *a priori* methods of his time —independent from experience— were unable to address real world problems— that is, those of specific communities and minorities; Thus the need to shift the attention of the design work from designing solution to enable participation, do-it-yourself practices and toolkits.

These values and ideals were also central to the life practices and social experimentations of American counterculture movements. As Fred Turner points out in his book "From Counterculture to Cyberculture" (Turner 2010), the discussion of hierarchy and self-dependency were quite influential on a particular group of environmentalists, representative of the future American intellectual class. This was the community that will contribute significantly to shaping much of theoretical foundations, values and views of technology that characterizes today's Silicon Valley corporations.

According to Andrew Kirk (2001), in his essay "Appropriating Technology",

> Before the end of the 1970s, organizations like Steward Brandt's Whole Earth Catalog and The New Alchemy Institute brought together some of the most innovative members of the counterculture to attempt to reconcile nature and the machine. (. . .) The research they promoted, in both alternative energy and alternative information systems, succeeded in substantially altering the way Americans thought about the power of technology as a benevolent force for environmental protection, ecological living, and personal liberation. (389)

Central to the forming of this revised view of technology and its basic principles is a particular interpretation of Marcuse's analysis of technology, that if technology is used amorally and un-ecologically, the problem becomes how technology is applied (Kirk 2001). What these movements were proposing to a society hit by an energy crisis, with low trust in institutions and where nothing was anymore at human scale, was a new utopia. Their approach was simple. Instead of trying to change society and the structure that vexed them, they thought they could build a new alternative one from the grassroots. A new constructivist and pragmatist

form of political and environmental activisms, based on the idea that technology could be designed to support the creation of new horizontal societies, organized around self-sufficient, communities of people, coordinated by computers and powered by distributed and alternative energy sources.

Communities experimenting in the new way of living started to pop up in the South West of the United States, experimenting with technologies, architectural solutions and social organizations closer to nature and individuals. Fuller's "doing the most with the least" was their motto and "the catalog" the source where they could find everything they would have needed to fulfill their needs: a magazine listing books, do-it-yourself instructions, information about technologies and new electronic devices. A strong contribution this vision was E.F. Schumacher's book "Small is Beautiful" ([1973] 2011) and his concept of "appropriate technologies": decentralized, energy efficient and people centered technological configurations in opposition to large scale and top-down government and industrial infrastructures. A concept that also highly influenced the idea of distributed energy production, or "Soft Path", suggested by Amory Lovins as an alternative to federal centralized strategies for energy supply (Lovins 1976).

Despite all the seditionary intents however, many of the ideals of social emancipation and sustainability that accompanied many the visions of distributed intelligence and social organization did not completely come true. On the contrary, according to Winner (1989, 61-84) these initiatives resulted more functional to the expansion of capitalist and industrial means of production rather subverting them. Instead of changing society, counterculture communities provided markets with new meanings and measures of productivity and efficiency, adding new criteria of judgment, such as "human scale" "Interconnectedness" and "Sustainability". As Winner notes, explaining the inadequacy and failure of the revolutionary plans of the counterculture movement, the main limitation to the reach of their action was that they did not question the infrastructure in place; the qualities, history and reasons behind certain technological turns. "Appropriate technologists were unwilling to face squarely the facts of organized social and political power. Fascinated by dreams of a spontaneous, grass roots revolution, they avoided any deep seeking analysis of the institution that control the direction of technological and economic development" (80).

Information infrastructures

Different but still incredibly visionary ideas of society and infrastructures driven by anti-modernist ideals and the desire to free society and individuals, can be found in some of the work done within architecture, infrastructure planning and interaction design that take place in these years. This represents a rich body of work that provided an essential contribution to our understanding of the design practice and our knowledge of human computer interaction. For instance, it is the visionary work of avant-garde architecture groups like Archigram in England and Superstudio in Italy that we can track down how certain visions and interpretations of society and technology have become part of our every day life. Although rejecting traditional architectural planning, social structures and discriminations of their time, the groups had slightly different theoretical and political views: Superstudio more leftist and critical while Archigram more celebrative of liberalism.

Despite these differences, their visual representation of hyper-connected worlds, flexible and reconfigurable infrastructures and spaces supervised by intelligent machines and dominated by the presence of displays, are equally forecasting of contemporary society, its provisionality and digital flexibility. When looking at Superstudio's 'Supersurface description today for instance, it is impossible to not associate it with what the Internet is and does today. Although most this work has never been produced, their contribution is extremely important also for another reason. They outlined a new role for the designer as a critical practitioner, crafter or perhaps influencer of alternative futures and possibilities outside institutions, policy and corporates dogma (Lang and Menking 2003; Sadler 2005).

To find more practical insights about the integration of information technology in to build environment though, we need to look according to the architect historian Molly Steenson, to the practice of architects as Cedric Price, Christopher Alexander and Nicholas Negroponte and their seminal explorations of relationships between people, planning activities and technologically mediated actions in space and possible directions for the design practice (Steenson 2014). In antithesis with modernist architecture practices they all looked at how to enable the responsiveness and adaptiveness of their design by increasing participation and opening up and mediating this process through software. Differently from conventional architecture though, they all focused their attention more on information's organization rather than the design and construction of physical

structures and buildings, thus pushing the boundaries of what was considered architectural.

These architects "formatted design as an information and computational problem, visualized informational paradigms in diagrams, charts and topologies, and built generative systems that modeled intelligence by incorporating methods from cybernetics and artificial intelligence" (Steenson 2014, 274). Price's buildings were materializations of networks paradigms where infrastructures were rendered visible and experienceable. As a way to respond to the flattening practices of top-down hierarchical planning, Alexander created a non-technical design pattern language with an open source object oriented code to guide the design of cities and buildings and deal with the complexity of urban settlements and human interactions. This developed a flexible glue to enable communities to collaborate in shaping their built environment according to context and specific needs. Negroponte instead was an early explorer of the new possibilities for human interactions through new media interfaces and computationally augmented physical environments, formalizing participation through software.

The future visions and materializations produced by these designers anticipated concepts of infrastructures and ideas that mirror today's consumerist and digital society. Representations and prototypes of alternative technologies and configurations that in someway prefigured some of the possibilities of Weiser's description of speculative "Ubiquitous computing" (Weiser 1993) twenty years afterword. Ideas of future infrastructures that can be said to be part of our present, although their reality is not as smooth and clean as it was depicted. These concepts and materials were in fact subject to the influence of social structures, pre-existing organizations and cultural mediation, their potential conflicts and re-interpretations (Dourish and Bell 2007).

With their researches they opened up new perspective on computational applications, largely informing the way we design interaction with devices and infrastructures today and influencing emerging areas of studies like open-source programming and architecture (Ratti and Claudel 2015). At the same time, they anticipated some of the pre-deterministic qualities of artificial intelligence. Through scripts and code, new order is created exposing the weakness of computer models as a freestanding means to engage and mediate publics, large groups of people with a plurality of objective and interests, into participatory processes (cf. De Carlo 1970). By bringing the design purpose and activities in the background of human

interactions —where we can no longer see them— they provided us with the foundational means and basics to articulate issues behind the mediation of digital infrastructures and the influence their organizations exert over human activities and their creative relations with object and space (Easterling 2012).

A postindustrial society?

When the sociologist Daniel Bell introduced and popularized the term 'post-industrial society', he described and predicted a broad ongoing transition from an economy based on the production of goods to one based on the provision of services (Bell 1973). Cheap manufacturing costs and market exhaustion would set the stage for this shift to this financial-service economy, making western companies change the focus of their production from the supply of a single product to the selling of combinations of products, competences and services jointly capable to fulfill specific needs. This transition would obviously have multiple impacts on multiple levels. For instance the emergence of a tertiary sector in the economy would have led to broad occupational changes from skilled and semiskilled workers in assembly lines to professional and technical jobs requiring higher educational background. Similarly it would have required a change in the way the value of a good or a service is determined and produced: from the amount of socially necessary labor required to produce it (which includes the procurement of raw materials and production of machinery), to a knowledge theory of value, where value is not increased by labor but by knowledge and know-how. Vital for this transition in Bell's view was the shift from centralized, large-scale linear infrastructures to distributed small-scale ones, and the change from logistic and material flows as key infrastructures and main arteries of the industrial economy, to immaterial flows of information and telecommunication networks (Bell 1976).

This description, while still largely depicting our society, also indicates the information and service economy we live in is one, in reality, more controversial than its predictions. Today's design space is characterized by a tension between the new socio-technical possibilities and demands and the permanence of industrial habits in the way we interpret society and technology. The result of this condition is a set of complex systemic and heterogeneous issues related to, just to mention some; sustainability, equality, legality, transparency, land use and local development. Constraints are exerted on global and local scales by the collective agency of competing networks as infrastructures, proliferation of standards and services and their constant transformations under the push of privatization and deregulation processes (Graham and Marvin 2001).

In this context government and active democracy have been overtaken by the logic and the rationale of the market and financial rhetoric. The operations of companies and financial lobbies are black-boxed and able to bypass the law of governments and the scrutiny of public and democratic organizations (Easterling 2014). Perhaps the most fundamental change in today's postindustrial society is, as Clive Dilnot suggests, the emergence of the world of the artificial. A new historical condition where the man-made is what constitutes the world and its laws and where economy draws upon technology to organize itself on a global basis, thus defining the politics of what is to come (Dilnot 2015, 175).

In this section I will attempt to articulate and provide a summary of some of the main features and dense phenomena that characterize the contemporary landscape of production and consumption. Starting from the 90s, the diffusion of Internet and broadband infrastructures enabled the experimentation of a variety of services and alternative business models that radically changed the way industry administrate and manage their businesses. The shift to a service economy and the hype for the new computational possibilities also invested the field of design that saw a shift of attention toward immaterial digital capabilities, user needs and customer experiences. Despite the greater opportunities for efficiency and coordination however, the dreams of instant liberation from centralized social control that accompanied the introduction of computers and distributed intelligence did not completely come true (Winner 1989, 85-97).

As Winner (1989) summarizes it, "while each specific area of production and distribution has its own history and distinctive mode of organization the overall pattern is clear. The social history of modern technology shows a tendency — perhaps better termed strategy — to reduce the number of centers at which action is initiated and control exercised" (93). Digital networks still depend on physical assets to operate. Satellites, antennas cables and data centers are still necessary for data transmission. High capital investment infrastructures that still share features of centralization and control with the railway systems and telegraph landlines of the early industrialization, supporting and allowing certain kind of activities and organizations and not others, but with a difference. Compared to the past, digitalization, privatization and liberalization processes produced more scattered networks; subtle instruments of power responding to the interest of their many owners rather than to publics (Graham and Marvin 2001). Sensing and computational capacities often ended up being incrementally applied on the top of existing industrial infrastructures according the same top-down planning logics and centralization criteria. Similarly designs and innovations addressing

issues of sustainable development have been often conceived within the same unsustainable capitalistic logic of growth and 'enframed' views of technology; a particular interpretation that makes us confuse sustainability with technical and economical efficiency, and that compels us to look at the world in terms of exploitable resources typical of industrial development (Fry 2009, 183-195).

The service and information society

The service and knowledge sector today accounts for a large part of both production and employment in industrialized economies (World Bank n.d.). It produces jobs and profit in almost any area – retails, catering, healthcare, education, finance and real estates just to mention some – and service innovation is widely considered a valuable business strategy for companies (Chesbrough 2010). Distributed intelligence and the introduction of Internet and wireless communication services played a key role in this shift, shaping the expectations about of technology by society and industry.

Over the years the massive standalone calculating machines of the Cold War have become networked desktop computers that reached into almost ever corner of the civilian word. As describe by Turner (2010) in his description of the origin of cyberculture in the 90s, professional networks like The Global Business Network and new magazines such as Wired, started to suggest the idea through articles and lobbying activities of their influential members that a new, networked form of economic life was emerging. Because of Internet and computer technologies it was finally possible "to move through life not in hierarchal and bureaucratic towers but as members of flexible, temporary and culturally congenial tribes" (238).

Through computers, software and code, people could finally collaborate in the production of things and sharing of knowledge and resources; personalize and re-appropriate content in real time and without location constraints. Concepts such as peer-to-peer, social networks and "open source" coming from software such as Linux (1992), started to alter the established relationship between producers and consumers, editor and audience that characterized the pre-Internet era (Ratti and Claudel 2015, 64-77). A new potential in the use and transmission of information for decentralized forms organization and collaboration that not only highly influenced the way market is shaped, but also permeated the structures of bureaucracy and defense (Turner 2010).

It did not take much for companies to realize the potentials and advantages of these new opportunities and the possibility to expand their business beyond traditional corporate boundaries. Companies started to collect data from customer's touch points as way to measure satisfaction and learn their preferences, while information technology started to be used to optimize time and material consumption and facilitate transactions and employee work. The new possibilities for corporate architecture offered by the World Wide Web also did not pass unnoticed. Young firms and start-ups realized that they did not need to organize work in a hierarchical and centralized fashion as they used to, but they could reorganize and radically modify service supply without the need to own an inventory or any physical assets beside one modem and 2GB storage. Exemplary of these new business paradigm ideal are companies like Amazon and its networked and just-in-time business model that allow other merchants to list their merchandise on its website. Founded in 1994 in a garage, as many other Silicon Valleys start-ups were, Amazon started operating mainly as a broker and having books distributed anywhere, anytime from existing warehouses and operated by other companies (Lyster 2012).

Service oriented and web-based business models started to be largely adopted as a competitive strategy and a more agile way to differentiate offer, reducing the risks of replicability of products. What became soon clear to companies was the way competition changed. In order to perform on the market they had to provide their customers with better experiences and solutions closer to their needs. To do that they had to provide them with the necessary information needed to understand corporates works and values and the necessary tools to be creative in order to open up for the co-creation of new user centered concepts. Open innovation, user centered methods and participatory design processes started to be integrated into design practices and product development (Sanders 2000; Von Hippel 2009). Xerox printing Services, iTunes, FedEx tracking and self-labeling system are some classic examples of companies' adoption of these approaches (Chesbrough 2010).

With the diffusion of personal computers at home and the progressive integration of computational capacity, mobile and wireless connectivity into everyday devices, interfaces and appliances an old-new vision started to develop among computer scientists. In a world that was becoming too complex to manage, computers were providing a means to make order: a new 'machine' one. Following trajectory drawn by Negroponte's work at the MIT architecture machine

group and exemplified by Weiser's research program on Ubiquitous Computing at Xerox Parc, a new idea of distributed intelligence started to emerge: one that does not reside in desktop computer anymore, but inhabits any object, artifact and device, invisibly supporting human interaction.

A broad set of experiments started to explore the new technological opportunities for integration of digital information in to the built environment. These were looking, for instance, at how to facilitate collaboration and productivity in work environments, facilitate commercial transaction and increase efficiency in cities and buildings through the automation of activities and systems. Along with these developments, many studies began to focus on the expressivity of digitally augmented artifacts and experience design. A field that contributed in to bringing important elements such ethnomethodologies, sociology and phenomenological perspectives in to the design field and in human computer interaction, as reflected by the introduction of ethnographers and field methods the design industry and firms such as IDEO, Xerox, Microsoft and Apple (Dourish 2004; Koskinen et al. 2011).

Bottom-up and distributed economies

Perhaps, the greatest effect of this broader access to information and technology has been its boost for grass roots and social innovations. Supported by an emerging body of tools, people started producing and organizing new services and activities that fulfill the needs of their communities, by reducing energy and material consumption and increasing sociality and knowledge share. These include a range of activities, from local farming, to DIY and Maker communities, to sharing platforms for spaces and equipment, to experimental networked production systems such as micro factories and fab-labs (Kuznetsov and Paulos 2010b; Manzini 2013).

These activities propose new ways of making and sharing things that largely build upon social innovation and the ability of people to develop solutions for them and their communities by inventing alternative ways of living and doing things to better meet their needs (Meroni 2007). Sharing platforms to offer and trade skills, share products, resources and competencies, networks of citizens producing and exchanging information and data about their cities and communities are all examples of collaborative services originally and spontaneously developed by people, and now easily accessible and implementable on a real-time

basis through websites, mobile applications, sensing toolkits and devices (Jegou and Manzini 2008; Townsend et al. 2011).

As John Thackara seems to suggest in "In the Bubble" (2006), the broad diffusion of these forms of innovation are symptomatic of broader social demands for more sustainable and responsive solutions in the way we organize food, energy, water, and manufacturing, more attentive to local needs and to the qualities of production, social relations and conviviality. A contextual sensitivity and local flexibility that the large infrastructures and corporations, designed to serve the needs of scale manufacturing and mass consumption as the foundations and arteries of today's society and economy, seem to lack. Among the possible causes of this intrinsic slow responsiveness, the creation and adoption of standards and their naturalization are probably the most influential.

When a particular version of a system or a technology acquire a critical mass of companies adopting it becomes a standard. The key point behind the adoption of standards is that they reduce the risk to manufacturers and reduce the cost to final consumers. However, while doing so, they also limit possible alternative systems configurations (Edwards 2003). Once standards are set, due to the high upfront capital investments made and the large interrelated network of stakeholders, suppliers, assets, jobs and activities depending on them, the companies' main concern is to inhibit any fundamental change in the system properties or radical innovation outside their standard performances and protocols (Hughes 1987). With passing of time the decisions that influenced the adoption of a certain standard, structure or form of organization become naturalized. They fade into the background and the purposes, practices and contingencies that led their creation are forgotten, unquestioned and taken for granted (Bowker and Star 2000).

All large infrastructures and their designs have been implemented to respond to the social needs of a certain society in a specific period of time, according to the cultural understanding of the problem they address and the available technological skills. With the passing of time though these configuration might not make sense anymore. For instance, Jonathan Lukens (2013), in its article about DIY infrastructures uses the example of flush toilets to show how the design of this particular kind of sewage system, responsible for water waste and pollution, is grounded in a scientific understanding on the spreading of diseases and hygienic norms largely divergent from the modern one. Today this sewage style is so dominant and so embedded into society that it becomes hard

to question it. In a similar way, the prevalent standardized and 'urbanocentric' designs of infrastructures still respond to criteria developed to serve the needs of mass production and consumption, which require large numbers of clients to be profitable and proximity to other networks on which they rely and clustering around infrastructural nodes. Criteria that certainly allow for advantages of scale and greater efficiency and control over the entire value chain, while optimizing outputs maximizing profit, but that today do not have the required diversity and local adaptiveness to alone provide appropriate support and sustainment structure.

In this context, according to Lukens (2013), bottom-up designs expose the limitations that socio-technical standards and protocols exert on society and the scope of design, by offering an alternative future and possibilities that better meet contextual needs, and thus a starting point for broader systemic change. It is probably for these reasons that in recent years a growing number of experts and reports started to identify in these bottom-up small scale and local business models the foundations for more resilient and sustainable infrastructures and new "distributed economies" (Johansson, Kisch and Mirata 2005). Their diversity, redundancy and modularity are in fact widely recognized as critical qualities for the flexibility and robustness of complex systems (Meadows and Wright 2008). This represents the starting of a long term mitigation and adaptation strategy able to address the economic structures and support local economies, while providing higher sustainability and labor opportunities in areas abandoned and geographically excluded by industrialization and the service industry (Biggs, Ryan and Wiseman 2010; Fiksel 2003).

The rebound effect

Despite the innumerable advantages and possibilities they offer, it must be acknowledge that information and automation technologies have a certain ambivalence and contradictory nature. This manifests itself in two ways. Firstly, although they allowed greater possibilities for collaboration and more efficient coordination of systems and services, the presence of a digital communication infrastructure did not change our relation with the physical world, our reliance on industrial hard infrastructures as a substitute for the need to move goods, people and information. As Thackara (2006) notice " A few years ago we hoped that digital communication networks would lead to a lighter economy and a cleaner environment. But this has not happened … the Information Age is heavier

than we anticipated. We supposed that an information society would replace the industrial society, whereas the information society has in fact been added to the industrial society" (10-11). It indeed had an impact on the wider economy, but it did not reduce the need to move people and goods or the need or the consumption of materials. On the contrary, it is contributing to increasing them (50-57).

The use of internet shopping services has increased the volume of traffic in cities, while brand's large warehouses cluster around main logistic hubs to increase their accessibility to the network, exposing some of the limits to existing transport infrastructures, transport and land use planning practices (Lyster 2012; Dablanc 2007). It is probably because of a recognition of the still high strategic importance of controlling physical assets in an economy of scale that Amazon soon understood that in order to maintain control over operations and shipments, it had to store books and other goods itself. This resulted in building its own warehouses and hardware infrastructures and developing its own proprietary technology and information to provide its service without interruptions (Lyster 2012). Online services still rely on fiber optic cables, broadband cell towers and landlines, while data farms – necessary for companies like Amazon, Google or Facebook to provide their services – still require large energy and resource demanding data centers to operate (Holt and Vonderau 2015; Starosielski 2015), while embedded electronics and batteries are responsible for many environmental concerns (Koehler and Som 2005; McBay, Parr and McLean 2014).

Due to their "physicality" and the criteria of scale and standardization that still characterize their design, these infrastructures are still the subjects and source of problems typical of the previous industrial era such as "digital divide" and "last miles problems". Which means that the accessibility to a certain service, like a FedEx mail drop box or the location of a fiber optic junction box for fast internet services by a company, still largely depend on the number of residents and population density and the possible economical advantages it can bring to it. As such they become the source of marginalization protest and inequality in access to services and resources in all those places that do not respond to industrial criteria. Cities, industrial and financial hubs have high connectivity, providing a competitive location for companies and businesses in a global market, while provincial towns and rural areas receive less, affecting their local economies by limiting the opportunities to properly support alternative business models and producing less occupational opportunities (Berg and Rydén 2012; Johansson, Kisch and Mirata 2005). At same time, the location of hard physical infrastructures, their presence or absence, whether power line pillars, a new railway or a

broadband antennas, are a source of public debate about the benefits for the community versus detriments for the few as the so called "not in my back yard" syndrome (Hill and Boyer 2013).

Contradictions and coercions caused by the new Internet enabled economy are not limited to "materiality". As much as for the previous industrial infrastructures and their internal innovation processes, new digitally enabled infrastructures and services maintain issues related to their agency, publicity and transparency. In addition, the existing regime of mass production and consumption seems to influence the diffusion of alternative business models imposing scalability constraints. While the sharing and social values behind the creation of socially driven and collaborative services have been re-appropriated by market purpose and logics.

In the conclusion of the book "Collaborative Services" (2008) Ezio Manzini and Fracois Jegou, in probably one of the first works aimed at visualizing and prototype how information technology could support creative communities in their everyday activities, wrote:

> Talking about up-scaling collaborative services, we are not of course proposing "to industrialize" them, meaning to consider them as products that can be mechanically reproduced on a large scale. Our discussion here is about whether and how it may be possible to apply to them a mix of creativity, design and entrepreneurial capabilities and technological knowledge (we can call this human industriosity) to make them more accessible and effective, and so help them to spread on a larger scale. (37)

What appears to be happening today is instead the exact opposite of what Manzini and Jegou describe. In his article "How deep is your love" for instance, Cuartielles (2014) offers an example of how external market forces and context influence the development of alternative business model and socially driven initiatives. Talking about his experience as a founder of Arduino, an open-source hardware platform programmable through a free programming software business initiative, he describes the cost limitations and struggles in maintaining a purely open, socially driven values within the current infrastructure space. His conclusion is that, in order to survive, to adapt and to find compromises with the existing market regimes is somehow inevitable, although this means to loose some of the main qualities that drove their original ideas.

A second example for this push toward growth and scalability, is the re-engineering of the genuine qualities of local, P2P, community sized solutions and their packaging into mass-market products: the so-called "sharing economy". Crowdsourcing, and collaborative services models are today quite popular among companies as a way to provide people with new services for their cities and make better uses of resources (Ratti and Townsend 2011). For instance, there are several examples of services whose business models are centered on the revealing and making use of the hidden and latent capacities in society. Airbnb for instance allows people to sublet their homes for short periods, Uber instead allows anybody with a car to provide taxi services.

The advantages of making underutilized things and capacities available from a business prospective are clear: "If you do not need to own the assets you use, not only do you spend smarter, but your product variety and quality options expand quite dramatically" (Sundararajan 2013). All these services provide a greater variety of economical advantages for individual users and members, by tapping in to the slow responsiveness of institutions in addressing the vested rights of long established transport and hospitality regulations. However, the scaling up of these concepts and the creation of new de-localized extended digital infrastructures is today opening up new questions about their potential impacts and implications on society at large, such as on the deregulation of labor rights; real estate market and the consequences on the social fabric of cities and communities (Dillahunt and Malone 2015; Zervas, Proserpio and Byers 2014).

A perhaps trivial but practical example of these controversies and how the agency of these system and the information they convey is becoming a matter of public concerns is the Los Angeles residents' protest against 'Waze'. This smart phone application provides free GPS and real time traffic data services to its users by harvesting information directly from their mobiles. The sharing of crowd-sourced mobility data about congestions on main highways resulted in increasing traffic in residential neighborhoods and secondary roads, causing safety and management problems to the city. As a response, citizens threatened the company by suggesting the possibility to hack and feed the app with misleading data in order to compromise its performance and reliability (Carney 2014).

What emerges from these examples is how qualities of size, scale and local diversity seem fundamental in maintaining the sustainability and sociality of bottom-up business models. However, it is also evident how the existing capitalist regime within which they operate influences their behavior and development.

Alternative practices and business models require a change in the way we design them, more aware of the possible consequences of their future mediations. At the same, to retain their qualities, designers need develop a facility with the underlying systems and forces that currently condition their development and create the appropriate environment for their introduction and diffusion.

Power and big data

Business models providing free access to platforms and services in exchange for data are extremely popular today and their scale and impact go well beyond a specific city or community. Several technology and software companies produce value by harvesting and re-selling the massive amount of data that we produce through the mundane interactions we have with a variety of artifacts and software that define our digital life, like laptops, web browsers, mobile phones and their apps, smart cards and security cameras. These practices obviously raise several ethical issues concerning privacy, surveillance and legitimacy, but at the same time they are the main tools for market optimization, scientific analysis and policy decision-making (Musolesi 2014; Boyd and Crawford 2012).

Typical examples of this meta-data market include the use of contextual data and machine learning algorithms to customize online advertisement and to provide localized services. Other more socially relevant applications of data aggregation and analysis can be, beside the great advantages in waste reduction in production and supply chains, the fraud protection systems that alert owners when atypical purchases are noticed in the use of their credit cards (Brunton and Nissenbaum 2011). Data from vehicular sensors also help to improve gas mileage and help automakers and institution to understand how to improve roads safety and prevent future accidents. Similarly, the aggregation of search terms related to symptoms has enabled Google to create a global flu outbreaks dashboard faster than the institutional ones (Brunton and Nissenbaum 2011). These implementations undoubtedly provide great individual and collective benefits. However as recent events such as the Wikileaks hacking and un-redacted release of diplomatic cables have shown, the collection and use of private and confidential information goes beyond these purposes when it is extended to diplomacy, financial planning, and policy making.

In the context of a society saturated with quantifiable data of a global economy, the owners and developers of broadband infrastructures, fiber optics cables,

data centres and machine learning technologies and are in a dominant and very influential position. And in a way they are not so different from the owners of the railways that preceded them. Through their networks and algorithms large IT corporations define power relations, decide who can have access to their services while providing governments, intelligence services, banks and financial institutions with the analytical tools necessary for their activities.

According to the Italian philosopher Franco Berardi, this rearrangement and new alliances between dominant groups are the result of a deal: "The Dotcoms —the several companies experimenting new business models that emerged and soon after failed in the early stage of the Internet era— have been the training laboratory for a productive model and a market. In the end the market was conquered and suffocated by monopolies, and the army of self-employed entrepreneurs and venture micro-capitalists was dissolved. Thus a new phase began: the groups that became predominant in the cycle of the net-economy forged an alliance with the dominant groups of the old-economy" (Berardi et al. 2011, 63).

Machine learning algorithms, co-location services and individual data feeds are extensively applied in the financial market. For instance, they are used to make predictions on states performances or in stock market activities such as "high speed trading", a practice that employs extremely fast machine for decision-making and manage incredibly high number of transactions in milliseconds. These solutions, according to experts, bring some advantage but also many concerns about the removal of human judgment from operations that affects millions of people, and about the influence of technology on fair competition. Economically more powerful groups that can afford the best algorithms can take higher advantage of their access to information excluding other competitors from the market. Finally, another source of concern are the possible consequences of the systemic interaction of dueling AIs and the potential crashes they can cause, such as the one that took place in May 2010 and that caused the loss of a trillion dollars in few minutes (Chordia et al. 2013; Kirilenko et al. 2014).

What is extremely relevant about big data is that despite its importance and the public implications, the ways the algorithms work, operate and for who are obscure to the majority of us. Once our data has been collected "We don't know whether the company that gathers it will repackage and resell it, whether it will become part of the schedule of assets after a bankruptcy, or whether a private party like ChoicePoint will be collating it with public records and reassembling it in a very different context from our original provision" (Brunton and

Nissenbaum 2011). Moreover, being a product of human invention, algorithms associate data in ways that are functional to their owners, they might reveal and highlight certain information but at the same time hide others. This is something that concerns all of us any time we browse something online or we use our mobile phone to find a restaurant, and are related to the many purposes and business models that machine learning applications serve in addition to the basic functionalities and motivation we identify them with (Pasquale 2015).

Agency and obfuscation

There is often a mismatch between what companies say they do and what they actually do. Keller Easterling (2014) defined this attitude as "disposition", a description of something about what an organization is doing, but that often escape detection or explanation. Thus, these activities also may diverge from the declared intents and promotional stories of a company, such as, 'This site uses cookies to offer you a better browsing experience'. Disposition describes an "unfolding relationship between potentials. It describes a tendency, activity faculty or property in either beings or objects–a propensity within a context" (72).

Infrastructures, according to Easterling, possess a disposition just as does a ball at the top of an incline. Here 'activity' might be assigned to the moving elements of this basic system, but is not necessarily the case. The geometry of the ball and its relative positions are markers of potential agency: even without rolling down the incline, the ball is actively doing something occupying its position. Thus a disposition is not something exclusive to the dynamic, visible digital and physical components of a technological system, but it is in intrinsic in its organization and arrangement, in what it does but also in what it does not do.

Infrastructures and technologies are 'active' in the sense that they conveys information about their potential applications and variety of uses they allow as much as a static object does holding its position in a room. Yet, information also resides in the actions and factors that led to their designs, configurations and purposes given to them. Legislative, verbal, digital and physical infrastructures are all equally active forms that, through their configuration, exert 'an agency' and mediate human actions (Easterling 2014, 71-80). This is what Bruno Latour called Actor Network Theory, for which both human and non-human inanimate objects are "active forms" (Latour 1992). It is organization, purpose and

associations they configure in a system, which becomes fundamental in defining how artifacts and technologies will influence our decision making, constrain and shape our actions, and those of other people and socio-technical systems (Latour 2005, 62-86).

The way algorithms and digital infrastructures work and their configurations are as much invisible and unquestionable as the back-end functionalities and structures required to operate and maintain many of the more mundane and naturalized infrastructures that surround us. Sewage, energy distribution systems, waste management, healthcare are all "industrial" and —in their original conceptions— "modernist" networks, now privatized and segmented in multiple peace and parts, on the top of which we started to incrementally add on technology. Structures conceived for other purposes and that inevitably influence the development of new forms and behaviors. Yet, despite their "publicity" in mediating and defining with their presence the possibilities for action, access and use of spaces and things, what these systems do, the purpose and logic behind their design are, for competition and security reasons, hidden to the judgment of citizens and publics.

This form of power is, according to Easterling, well understood by corporations and financial lobbies that use infrastructures as the means to accomplish and to administrate their interests. To achieve their scopes, quasi-official forms of governance like world organizations, trade associations and financial consultancies have been created above the scrutiny of states and democratic institution as a way to provide the right conditions for their businesses. It is in this infrastructural space, or "extrastatecraft", that the "most radical changes to the globalizing world are being written, not in the language of law and diplomacy, but in these spatial infrastructural technologies" (Easterling 2014, 15).

In the liberalized and unbundled context of today's society, where most of the basic services to allow society to operate have been privatized and therefore moved by private motivations rather than public interest, understanding the purposes and logics behind forms and configurations of infrastructures, institutions and their services is fundamental to understand their agency and power relations. In particular this becomes important to articulate strategies to initiate change in these systems, to understand how to evolve them and towards which direction.

As we previously saw in this chapter, capital and industry continuously reorganized themselves to include concepts and ideas of technology that may be considered originally adversarial to them. For instance open, shared and collaborative services have been rendered functional to the production and access to commodities not exploited before, such as the latent availability of apartments and workforce. From these examples, it is possible to see how the design of bottom up services and infrastructures still maintain criteria of problem solving and centralization functional to capitalist development and expansion logics that characterizes our western development since the 50s. Design criteria motivated by a very particular interpretation of technology, nature and society (which is addressed in the following section) that now appear to be 'de-futuring', and thus limiting our possibilities to design and conceive alternative futures outside of this world view (Dilnot 2015).

Indeed, the evolution of technology increases the need of human skills and competences, but at the same time it appears to produce, in its current configurations and designs, a variety of problems associated to the agency of infrastructures and the practices they supports. The scale at which these networks now exert their powers and the amount of people affected by their design and purposes has changed. As a consequence, the effects of their dispositions and mediations are perhaps less intelligible, and not directly experienceable locally or in our everyday lives. Nevertheless, the permanence of industrial modes and habits in the way we conceive these infrastructures and their agencies do have several tangible impacts on society, labor and the environment.

For instance, the still high relevance and concentration of physical assets (building, equipment, technology, patents) in the hands of the few members of society, represents, according to the economist Thomas Piketty (2014, 234), an important contribution to the inequality of wealth distribution in western societies. Moreover, a growing number of scholars and sociologists are now calling for attention to the emergence of new forms of "informational capitalism" associated with automation and manufacturing practices and to the new forms of social injustice, labor exploitation, unemployment they might cause (Berardi et al. 2011; Fuchs 2010; Qiu, Gregg and Crawford 2014).

Similarly, practices like data-mining, not only raises issues concerning privacy and legitimacy but calls for a debate about the creation of a new form of "immaterial labor" aimed the creation of immaterial products like, knowledge and information, based on human relationships and emotional responses. Knowledge and

commons produced by communities and public institution from all over the world (e.g. schools, parks, libraries, museums), and with a cost (e.g. the taxes needed to maintain and operate them), are commoditized and used by private corporations located in specific geographical areas of the globe in exchange of basic services. This generates a discrepancy between the cost of work and the value produced that, along with its unequal redistribution, inevitably affects local economies (Hardt and Negri 2005, 103-115; Terranova 2000).

As Brunton and Nissenbaum (2011) illustrated in their article "Vernacular resistance to data collection", the reliance on big-data and their collection requires a deeper political and critical discussion about the ability of law and institutions to guarantee the privacy and the rights of citizens. Introducing the concept "obfuscation" as a set of practical tactics for self-defense aimed at confusing and rendering data collection useless, they open up an interesting (design) space about legality and ethically justified forms of disobedience such as hacking. The LA citizens feeding the Waze app with fake information is typical of these tactics and issues. Another example reported by Brunton and Nissembaum is 'FaceCloack' (Luo Xie and Hengartner 2009) a web browser's plug-in that acts as a mediating layer between a user's personal information and social networking sites. As a way to avoid personal data misuses and increase privacy FaceCloack creates and stores an encrypted profile with the real information of its user that can be displayed only to authorized friend. At the same time it provides the social network with fake identities. The social networking site never gains access to the real information. By doing this FaceCloack obfuscates its methods, avoiding the collection of metadata and associating them with a real identity.

The concept of obfuscation can help us articulate relations which are critical to understanding how much of contemporary design is actually done, as an action starting from the recognition of new needs and possibilities caused by events and situations that destabilize what already exists within a given design space. Obfuscation express and exemplify a way to design for solving problems that lead us to the creation of vicious loops of actions and counteractions that technology and big data trigger. In other words, the more people start to learn how 'to blend' and evade control, the more secure technologies and intrusive data collection techniques are developed; while the more technology is integrated into our life the higher are the risks associated with hacking practices and the disclosure of private information (O'Connor 2014; Crawford 2014).

The invisible infrastructure

When thinking about what it is now necessary to evolve infrastructures in order to meet new social needs and demands, we can clearly identify a divergence between the 'invisibility' of the disposition of infrastructures and the 'public' implications of their agencies. Except when they 'breakdown' or they start manifesting tangible side effects, functionalities and operations of these systems are often inaccessible, hidden under the surface of human interactions (Star and Rohleder 1996). Considering the influence that infrastructures have on people's lives and the conflict that characterizes much of their planning and implementation, this concealment has, although partly justified by security and reliability reasons, several social implications.

Using Albert Borgmann's words, what is interesting to notice is that when planning discussions about infrastructures and their purpose take place "value talk conforms to the abstract and narrowly defined character of commodities" (Borgmann 1987, 81). That is, with some exceptions, the construction of buildings, machinery and devices that allow highest economical advantages in the shortest time and in ways that subtract infrastructures and their development from being objects of critical inquiry. In these negotiations, the different power relations between the various stakeholders involved often end up in making some plan and motivation prevailing on others, and "in the process by which structuring decisions are made, different people are situated differently and posses unequal degrees of power as well as unequal level of awareness" (Winner 1989, 28).

These observations open up several questions concerning the ability of citizens to question and participate in and influence design decisions, as well as about the ability of designers to properly assess the consequences of their solutions and the influence that pre-existing configurations might exert on future ones. (Winner 1989, 19-29). To fully understand these concerns and their implications for the design of new networks and infrastructures, requires to first find ways to properly articulate what does it means to say 'infrastructures are invisible' and to better address the meaning and origins of this concealment.

For this purpose, this chapter will introduce and summarize a set of concepts and philosophical positions useful to unfold 'invisibility' and its significance. This is not meant to provide a precise and contextualized analysis of these ideas but to

illustrate how I make use of each for my inquiry. Starting from the phenomenon of 'naturalization', I will then introduce and summarize Heidegger's perspective on 'technological enframing' and its connection with Borgman's concept of 'commoditizion'. Finally, as means to articulate what renders people unable to question and participate in the discussion and decision making about infrastructures I will introduce John Dewey's definitions of 'public and habits'.

What emerges from the philosophical analysis is that invisibility is not simply a description of physical and visual qualities, but is intrinsic in the prevalent way we design things and how this is deeply rooted in a particular interpretation of technology and nature that is common in our society. This form of concealment is not directly addressable only by means of providing higher transparency and intelligibility through means of descriptions and explanation, or by opening up the design of a particular infrastructure to participation and collaboration. To counteract it will require the elaboration of methods and practices that go beyond solving problems within specific contexts and communities, allowing for a more dispassionate and comprehensive judgment of a current situation, its future configurations and their possible consequences.

Making work invisible

> The more naturalized an object becomes, the more unquestioning the relation of the community to it. (. . .) Light switches for instance are ordinary part of modern life. (. . .) People do not think twice about their nature, only about whether or not they can find them when needed. Commodities and infrastructural technologies are often naturalized in this way. In a sense they become a form of collective forgetting, or naturalization, of the contingent messy work they replace. (Bowker and Star 2000, 299).

This description of 'naturalization' from Goffrey Bowker and Susan Lee Star provide a first important keyword to interpret how technologies, standards and practices often remain unquestioned. With the passing of time, objects and devices become natural in the life of a community and the motivations and needs that led to specific styles, forms and organizations, are taken for granted. They are 'learned as part of membership' by the communities and societies that use them, 'shaping and shaped' [9] by conventions (Star and Rohleder 2006).

9 The naturalization of a given design shapes conventions. The QUERTY keyboard standard for instance was designed to solve problems related to mechanical typewriters but is still present in modern computers.

The social implication of the process through which work is replaced by devices and become invisible, is also at the center of Alfred Borgmann's philosophical inquiry of technology (Borgmann 1987, 35). According to Borgmann in an economy based on the supply of commodities, prevalent modes of technological development keep us distant from what he calls "focal things and practice" (Borgmann 1987, 196-210). These can be summarized as the ultimate concern about the meaning of technological applications and their role in society. 'Ultimate purpose' that is today concealed and rendered unquestionable through what he defined as the 'device paradigm': the separation between the means of production or the work necessary to produce something, and its ends as the commodity made available by it in the form of a final product or service.

According to Borgmann the main promise of technology is that of enlightenment, or "to bring the forces of nature and culture under control, to liberate us from misery and toil and to enrich our life" (Borgmann 1987, 41). A prospective that is largely drawn on Hidegger's questioning of the relation between humans and technology for which this latter is essentially a 'enframing' by making available and revealing nature as a standing-reserve for production (Heidegger 1977). A way to look at nature and society which is a foundation of the modern western capitalist enterprise, and that is descriptive of its interpretation of world as a potential source of energy, raw material and profit that can be harvested through measurements, labor and machineries (Feenberg 2000b, 311).

The essence of this domination is, according to Heidegger, *aletheia*[10] the action of revealing and mastering nature through science and physics in order to subjugate the unknown and turn it in to own advantage as a 'standing reserve' (Heidegger 1977). If the prevalent use of science and technology is aimed at making a yet uncontrolled and unknown phenomena 'transparent' in order to extend control over it, yet another outcome of this process is to make something else invisible and black-boxed: namely the functionalities and operations of the technology itself.

As Borgmann argues, the use of technological devices, infrastructures, mass production machineries and labor organization strategies, are mainly aimed at the production of commodities and their consumption. Using scientific, economical and technical arguments for advancement, end-results are incrementally

10 Yet *aletheia* offers an interesting concept politically as well, as the action of 'revealing truth' and making available something to others.

commoditized and made available and accessible through devices easier to use and produce. But at the same time they hide the complexity of the systems they allow users to interface with.

Indeed during the 19th century and early industrialization this use of technology was an important means of liberation and enrichment for human lives, however, the permanence of the same patterns and criteria in the modern era represent for Borgmann a matter of concern (Borgmann 1987, 57-68). According to Borgmann one main implication of the separation between means (the work necessary to produce something) and ends (the commodity made available in the form of a final product or service) has impacts on the social practices and contextual relations around work and, in particular, limits our ability to relate to 'how' work is done and its purpose, concealing and rendering it inaccessible for judgment.

The classic example provided to describe the effects of this 'Device Paradigm' is the difference between the fire stoves that characterized rural life at the beginning of the 20th century and central heating. While the maintenance of the fire required families to organize activities around it; dividing work and creating roles and responsibilities such as chopping the wood, control it, cooking with and so on, within the community around it, central eating does not. It makes heat directly available, hiding the work necessary to produce it, disburdening us from any other responsibility and making no demands in our skills (Borgmann 1987, 42).

Technological sophistication makes it easier to provide end-results, at the same time though it makes it difficult for users to understand how devices really work, thus preventing their users repairing or adjusting them to their contextual needs. Commodities provided by a device render people passive consumers of it at an individual level, removing the social interaction and control around their consumption and supply. Moreover according to Borgmann, scientific and technical knowledge used in the creation of devices used as means of control on the production output contribute to decontextualize their end-result through standardization.

"In a device, the relatedness of the world is replaced by a machinery, but machinery is concealed, and the commodities, which are made available by a device, are enjoyed without the encumbrance of or the engagement with a context" (Borgmann 1987, 47). He exemplified this concept through the use of chemistry

in industrial wine production and the use of machineries and substances to control and homogenize the quality of the wine, removing contextual factors that would otherwise determine its taste, changing it according to the season or particular contextual conditions.

The flattening and reduction of devices to an interface and the inability of a commodity to express the factors that defined its final form prevent us from 'fully understanding' and judging the criteria and motivations that led to its final configuration. Similarly the black-boxing of the back-end work and operations necessary to produce devices and commodities makes us unable to relate to the possible negative effects and environmental, social and economical implications that their manufacturing and supply operations might have on our lives.

Habits and publics

What emerge from Borgmann's inquiry on the device paradigm is how the means-end configuration is fundamental to understand our society and its values. This perspective on work and use of technology and their social implications are central to reconsidering our relation with it and how to possibly re-address its purpose toward more socially meaningful and "focal" practices. In her book 'The Human Condition' (2013), Hannah Arendt defines ends as "those human achievements that are firm and enduring and provide humans a secure and common dwelling place" (as quoted in Borgmann, 1987, 58). The concept, 'common dwelling' becomes central to articulate some important ethical question regarding design, technology and their public implications in light of the contemporary global setting, the scale at which they operate and its consequences on society at large.

The original meaning of the word ethos in Greek is, as Nancy points out, dwelling and "the creation of a well accustomed place" which is, in a way, closely related to Nelson Goodman's idea of 'world making' (Nancy 2007, 10). This concept is a strategy for making sense of the world and its essence by recognizing it as an assembly of multiple perspective and conflicting truths. For instance inductive validity as the form of reasoning used by science and philosophy is for Goodman "one example of rightness and truth but is also one of the criteria applied in the search for truth". It is one of the possible ways to look and interpret the world and one of the ways of making sense of it (Goodman 1983). Recognizing this diversity of worldviews is a first initial step to better interpret what makes

something "well made" and understand qualities and agencies of possible design configuration. Philosophical concepts that, as suggested by the architect and urban planner Nel Jannsens, can be synthesized through the word "Worlding": a way "of creating a viable form of inhabiting" which include diversity of social, political, and poetical values against the dominant universalism of the current socio economical paradigm (Janssens 2012, 52-58).

The design and definition of infrastructural arrangements and the dispositions of their devices do represent a form of "common dwelling" and a matter of public concern. As such, to be considered ethical and 'good', the design inevitably has to include a diversity of perspective. The recognition of diversity alone, however, might not be sufficient to guide the design action. As the theologian David Tracy argues in his "Plurality and Ambiguity" (1994): "To experience is to interpret; and to "be experienced" is to have become a good interpreter"(Tracy 1994, 9). Thus, the interaction between interpreter and the interpreted—the designer and the people he design for— is not univocal but also the design action need to be transparent and interpretable by those who will be affected it. Nevertheless the black-boxed way through which socio-technical systems are today designed and invisibility of their operation do not allow for this exchange and multiplicity of interpretations.

In "The search for the Great Community" John Dewey (1954) addressed some of these issues, observing how "there can be no public without full publicity in respect to all consequences which concern it" (167). There exists in this sentence a certain incompatibility between the "publicity" required by society in order to judge and participate, and the possibility for the commoditization of these systems and naturalization over time in their configurations. To fully understand what does this mean though, it is first necessary to explain the Deweyan definition of 'public'.

Public is, according to Dewey, an entity composed of multiple actors with diverse and divergent interpretations, brought into being through a situated issue for the purpose of contending with these issue in its current state and in anticipation of its future consequences. The idea that the public is constructed is central to understand the rest of the sentence. Public and democratic participation cannot be triggered by the awareness of a problem itself. But public is 'the action' of participation in a discussion regarding a matter of concern and accomplished by heterogeneous communities with diverse interpretations and perspectives. As a result, democracy and communities become such only when people can

recognize their actions and consequences associated with these actions, actively participating in the resolution of common issues.

What makes Dewey's analysis so appealing from a design perspective, is that from his philosophical stance any investigation regarding matters of public concern cannot be separated from the 'facts and experiences' of every day life. In particular he suggests that problematic situations and matters of concern can be given a form and rendered experienceable and used to engage people in the process of understanding how to re-direct development (Dewey 1954).

According to Dewey "experience" is the fundamental means of inquiry and source of knowledge in the world (Dewey 1987). Social analysis, scientific descriptions and technical explanations alone are not sufficient to prescribe action. But proper 'signs, objects and symbols' embedding these disciplines and different forms of knowledge are necessary to provide people with a 'sharable experience' of a matter of concern; thus to allow people to relate to them, enabling judgment and participation in the resolution of common issues through the recognitions of actions and their consequences. To be fully perceived though, an experience requires an "active self" which means that the receiver of the work not only needs to engage but also shape action through a full relationship with her environment, body and emotions (Dewey 1987). This condition however, does not really occur in the every day life interactions and relationship between citizens and institutions.

Dewey identifies two main limitations to the enactment of publics and the democratic evolution of its infrastructures. The first is represented by social 'habits'; the second is the inaccessibility and low transparency of institutions and infrastructures caused by these habits. Habits are an intrinsic conservative force that binds societies to orderly and established ways of action, framing thought within predetermined channels. They provide an ease and sense of safety that avoids exploring different ways of doing things to just keep and maintain the status quo, to preserve power and recognition (Dewey 1954, 160). For instance, the way companies avoid any radical systemic change or innovation once the gain momentum and their production standards and operation protocols are consolidated (Hughes 1987) is a form of habit[11]. Another form of habits is for

11 As Hughes (1987) illustrates, once infrastructures reach a certain scale, including different branches and suppliers, the management and maintenance of the system and its subparts become central to sustain it and guarantee the survival of all the stockholders that depend on it. This includes governments and the interests these have in maintaining labor and revenue. This relation between states and infrastructures is deeply histori-

Dewey the maintenance and categorization of knowledge into specialized fields according to which companies and institutions are still organized. Specialized vocabulary and division between theory and applied knowledge are, according to Dewey factors that contribute to the exclusion of citizens from the democratic participation and discussion regarding infrastructural matters.

The division between disciplines is for Dewey problematic. It does not correspond to reality, where all forms of knowledge - scientific and humanistic - are correlated and experienceable together in the world. History and sociology, physic and chemistry, engineering and architecture are all treated as separated topics and in an "abstract" division between theoretical and applied sciences, such as body and mind, but in reality they all coexist. They are all embedded together in the world and described as 'sense-able' qualities of a phenomenon and the consequences of certain actions. In addition, the elaboration of scientific and technical terminologies keeps people away from fully understanding and perceiving the motivations and consequences that are behind decisions. For people external to these systems, the only possibility to relate with them is given by their front-end devices, their practical affairs or when they are suddenly affected by their top-down decisions. For example, they use telephones and light bulbs but they do not know, if not superficially, how the energy infrastructure is managed and how decision are made in its regard and by not understanding "how" they cannot judge nor control them, but only be affected by them (Dewey 1954,165).

Another form of invisibility and conservatism is the way the division of labor and professions within companies contribute to detaching employees from the products of their work and their possible heteronomous uses and consequences. As portrayed in Harun Farocki's documentary "Unextinghusihble Fire", employees become units in a production system that is invisible in his totality: the chemist employed in a large corporation thinks she is developing a chemical compound for fertilizers while the company intention is to use it for napalm production (Farocki 1969). Along these lines, Samuel Weber, describe professionalism and the development of highly specialized technical work languages as the mechanism through which established corporations and institutions respond to an 'anxiety'. They provide status by regarded practitioners as possessing a monopoly of competences in their particular field but, at the same time they

cal. With the development of 'modern' infrastructures, cities, dwellings, products, knowledge, professions, activities and their processes started to be planned, designed and organized according to scientific and rational methods, and functional to the needs of the industrial regime of production and the society it served (Noble 1979).

respond to a need to control and maintain power and identity in front of a dynamic and continuously unsettling world and society (Weber and Godzich 1987, 27).

Habits can be therefore defined, says Dewey referring to Freud's work on human phobia, as "a social pathology that works against any effective inquiry of social institution and conditions " (Dewey 1954, 170), in a defense strategy based on making themselves not understandable. An analysis of the current system of production and its organization not so distant from Marcuse's critique for which technology and rationalization behind mass production and consumption are the means to impose one particular world view and order on society. In other words, "nature scientifically comprehended and mastered reappears in the technical apparatus of production and destruction which sustain and improves the life of individuals, while subordinating them to the life of the apparatus. Thus the rational hierarchy merges with the social one" (Marcuse 1991, 166).

Estranging the paradigm

From the summary of these philosophical perspectives and social studies on technology what emerges is the existence of a paradigm that invisibly frames the way we look at the world and subtly contribute to the creation of social habits around work organization and practices. Its presence is therefore not directly experienceable although some of the patterns of its presence, which are manifest in the way we currently design and apply technology. The way we recognize problems, select purpose and solutions are mainly framed within the boundaries of capitalism and consumerism through the replication of patterns and criteria defined in the early stages of industrialization. Due to the invisibility and concealment of functionalities and design practices and decision-making processes that led to a specific configuration or device, the presence of the paradigm is often unquestioned. Therefore judgment regarding the appropriateness of a certain solution, its purpose and end result becomes impossible. Considering the postindustrial settings in which design is required to operate and the increased number of users and citizens affected by design decisions, the permanence of certain design habits is becoming a matter of public concern. Without full intelligibility of the functionalities and principles that guide the design of systems affecting people's lives, there cannot be a proper democratic evolution of our institutions and infrastructures.

It is not simple to break with the accustomed habits of work and design that led our society to prosper and improve the quality of life. Nevertheless, the possibility to enable change to our production and consumption systems today is largely dependent on our ability to identify the means to deal with this new complexity and the invisibility that characterizes much of the design activity, its product and purposes. The shift from an industrial society to an information and communication one have shaped a new set of needs that seems to be hardly solvable through specialized professions and practices typical of the past century. When dealing with complex and heterogeneous problems involving a variety of stockholders and interests like sustainable development, descriptions and explanations of scientific analysis and technical arguments alone are no longer sufficient to prescribe action and come to decisions (Nelson and Stolterman 2003, 134).

To succeed in this intent requires us to find methods of inquiry and processes that elude subjectivity of interpretations and create modes for collective understanding of the purposes and consequences of future technologies and socio-technical configurations. Multidisciplinary approaches, attentive to diversity and plurality of views are necessary. As Dewey suggests, knowledge about these systems should be condensed, translated and made accessible and situated in people's experience of their every day life (Dewey 1954). Due to its ability to express, materialize and synthesize problems and solutions, design practices seem to have the necessary knowledge and culture to produce these dialogical means to engage people with different expertise and levels of knowledge in exploring and discussing matters of concern. However, traditional and prevalent planning and design processes and approaches developed to serve industrial needs and aimed at solving problems for a specific community or client might be not sufficiently equipped for this purpose.

Perhaps, the right analogy to summarize what a future practice dealing with infrastructural change might need to include and provide is Bertolt Brecht's notion of 'Estrangement' (1964, 91-99). A technique used in Chinese acting to hinder the audience from simply identifying itself with the characters in the play by enabling their ability to consciously judge, accept or refuse, their actions and utterances during the play. In this way, spectators are persuaded against subconsciously assimilating the work of art in its whole, empathizing with the characters and their perspectives, and are allowed to critically judge the events by singling out the different decision that led to the development of plot. The audience becomes

observers of the actor, while the ability of the latter is in triggering questioning and disclosing through a performative dialogue on the mystery of human nature.

Following a similar logic, the industrial design practice might persuade its clients about the goodness of its action, avoiding them to fully evaluate and experience the possible effects and consequences of new products and services in their life. Moreover, concealment of devices' functionalities inhibits people's ability to critically question the operation of the systems and infrastructures that actually determine the origin of an issue, and the appropriateness of the processes and methods employed to address it. As a response to this opaqueness, design means and methods could be aimed at exposing the presence and consequences of the current paradigm of production and consumption, making the agency of infrastructures and their present and future configurations, present and available for judgment and questioning.

This does not mean, to allow transparency and participation in the design process only, but to open it up, allowing people to interpret the reasoning of the designer and the motivations behind her actions. As Brecht says, referring to the Chinese actor "how it is done remains hidden: knowledge is a matter of knowing the tricks and is in the hands of a few men who guard it jealously and profit from their secrets" (Brecht 1964, 96). Designers then will always make and materialize future possibilities and suggest what they consider to be preferable. What is different though is number of clients and actors that they will be required to invite and mediate in between in the design process and how and where this dialogue and interaction will take place.

The industrial habits of design

The permanence of a particular way of thinking about design and technology seems to be the source of many of the issues regarding the scale and agency of infrastructures that invisibly define the design space designers are required to deal with today. As we saw in the previous chapters, the increase growth of networks of infrastructures, their privatization and digitalization altered the relationship of scale between systems and their front-end interfaces. Conditions that amplified the number of users indirectly affected by the design of products and systems in ways that are not directly perceivable or possible to anticipate before use.

With the evolution of society and technologies new disciplines and approaches have been included in the design curricula to deal with the increasing complexity and usability of new technologies and to address social inclusion and sustainability needs. Despite these important contributions however, we are still mainly relying on the same industrial foundations. Practices, knowledge and approaches that now appear insufficient to address design problems that do not only concern particular users or isolated systems, but their mediations and systemic agency.

Indeed, the increased involvement and attention to users needs has offered an effective way to avoid the artifact not being accepted by the community of practice they were intended for, democratizing the design process. However, co-design and user centered practices are still often aimed at the provision of end results for specific communities and categories of people, while their activities still largely take place at the fringes of existing infrastructural arrangements. These features might limit the ability of participants and designer to solve present controversies and fully anticipate the effects of the systemic interaction of their solutions. Similarly, they raises concerns about the ability of these practices to truly challenge the infrastructural dispositions and power relations that actually determine the situation and the design space they are trying to address.

Moreover, the appropriation of these approaches by marketing and business units and the naturalization of a certain interpretation of the design profession raises questions about what is the subject and purpose of design today and the foundations of its practice. These issues concern the design's own relation to industrial mass production; the ability of current industrial methods

and approaches to properly address the design of digital services and business models and the designers own consciousness and responsibility for their actions and the products and systems they design.

The systemic limits of industrial design

Concerns about the radicalization of design practices and their subjugation to market rationalities were already expressed by John Chris Jones, in the 70s. In particular, at the center of Jones' analysis is the inability of prevalent design methods to deal with the increased complexity of society; the scale and the systemic agency of its technical system. According to Jones, design being an industrial practice it's in a way co-responsible for the entangled systemic problems produced by the use of man made things and its un-regimented growth of technical systems (Jones 1992). Waste, pollution, urban decay, traffic congestion, road accidents, inequities in access to healthcare and education services, are all failures of systems once designed without considering the collective interactions of different products, standards and services.

As Jones argues, some of the main reasons behind the inability of designers to anticipate these issues have to be found in the way design were professionally organized. Design was optimized to serve industry and mass production through methods and processes that divided the production of artifacts from their use, separating the act of designing from the context of use. In Jones's time, scale drawing, models and computers were often used in place of the product as a medium to explore possibilities for change. These practices, according to Jones, simplify reality, determining uses excluding from this evaluation contextual influences and agencies of the product in use. A way of working 'in the studio' that relieved designers from the responsibilities about the agency of a certain product in the world since their control ceases before the production process starts.

To support his argument Jones uses the example of wagon-making in the 19th century. The shape of a wagon was not defined *a priori* but was the consequence of an evolution of the artifact through a trial and error process in which the environment and day-to-day experiences of use determined the development its final shape (Jones 1992, 17). These relationship between context and artifact, form and aesthetics, ceased to co-exist with industrial manufacturing. Jones therefore argues about the necessity to evolve design methods, shifting from a practice focused on the provision of incremental solutions at the front-end of networks

and systems to one that questions its own foundations. A practice not only aimed at materializing new ideas but also how to enable change within existing physical and organizational configurations that might be limiting the scope of its action:

> New needs grow and old ones need to decay in response to the changing patterns of facilities available. To design is not longer to increase the stability of the man made world but it is to alter, for good or ill, things that determine the course of its development. This question of the instability of the present under the influence of technological changes planned in the past and coming about in the future, is perhaps the hardest thing to get used to. It is still difficult to accept the, by now, rational view that the investigation of existing needs is not necessarily any guide to what people will want to do when new technical possibilities become available. (Jones 1992, 33).

According to Jones (1992), decisions about a possible technological application are no longer a matter of fulfilling needs, but 'a choice' about a future solution that has political and ethical implications regarding the possible consequences of its implementation and uses. At the same time, problems at the systemic level are not anymore addressable by small groups of experts and their particular interpretations and analyses regarding a matter of concern, but they require the involvement of all the stakeholders who will be affected by a new configuration. If this was possible in early industrialization – when the social needs where basic and demand still high - the issues we are required to deal with today seems to exceed the rational problem solving skills and capacities of one mind or of a skilled team through the 'simplifications' of traditional industrial design process —Ideas that in many ways recall some of Dewey's reflections about publics and professionalization.

The knowledge gap between the designer and context has been progressively reduced through the introduction of ethnographic and participatory practices. With the maturity of markets and the diffusion of new media, technologies and devices, corporate strategies became more and more challenged to bring production in line with complex demands coming from society. This socio-technical change required a substantial shift form focusing on the production of goods only to the provision of contextual and systemic knowledge about users and their lives. This was knowledge that traditional usability criteria, scientific methods and cognitivist approaches in vogue until then were not able to provide.

The user-centered turn

The origins of participatory practices are grounded in Scandinavia were they were initially explored and conceived as a mean increase the value of industrial production by engaging workers in the co-development of new systems and applications for the workplace (Bødker 1996; Bjerknes, Ehn and Kyng 1987; Ehn 1988). Starting from the fundamental understanding of organizations as inherently full of conflicts, participatory design started from the basic and democratic standpoint that those affected by a design should have a say in the design process (Ehn 2008). In similar times, around the 80s-90s, user centered and ethnographic approaches began to be adopted as an approach to define product qualities based on people's needs and to guide the introduction of radically new technologies such as personal computers. Designers, ethnographers and sociologist started to be largely employed to observe and involve users in small exercises to have feedback about new devices and their features in their context of use and under ordinary every day conditions (Suchman 1987; Szymanski and Whalen 2011).

The main difference between ethnographic approaches and participatory practices is that if in the first the difference between users as subject and designers as experts is clear, in the latter designers and researchers are enablers. They provide participants with the necessary materials and resources to reflect about their context and practices by co-designing and envisioning future solutions together (Sanders and Stappers 2008). Toolkits and 'design games' are generally crafted and employed as a dialogical means to bring participants' 'tacit knowledge' into play in the design process and collaboratively explore alternative configurations (Bjerknes, Ehn and Kyng 1987; Ehn 1988). This distinction however is not so pronounced anymore.

As I will examine more in depth in the second section of this dissertation, these methods and approaches are now continuously evolving, and hybridizing, taking different forms and perspectives depending on the mindset and expertise of the practitioner; the level of engagement and inclusion of participants, and the purposes of the project. For instance a recent attempt to develop a hybrid practice between design and anthropology comes from the Danish School of Design. Here design games and concepts mockups are used to unfold and articulate issues and include diversity of interpretation in the design process through the exploration and rehearsals of possible concepts in the field (Halse et al. 2010).

Despite their differences user centered and participatory practices are recognized today as important instrument for the co-creation of value between companies and customers (Sanders and Stappers 2008). Their tools and techniques are largely integrated within design consultancies and corporations Groups like Intel and Proctor and Gamble for instance, still hire social researchers to help them gain insight into user desires with the ultimate aim of gaining greater market share and ensuring more predictable success with new product lunches (Hunt 2011). The diffusion and success of these methods is symptomatic of their efficacy in providing solutions closer to people's needs. However, participatory design practices, as conceptualized above, are not immune to obsolescence and some of their qualities might actually represent a limit to our ability to address present problems.

For instance Pelle Ehn, one of the founders of the Scandinavian participatory movement, in his paper "Participation in Design Things" notices how in many cases participatory projects are still limited in production timeline and in addressing the needs of identifiable communities and categories of users (Ehn 2008). Moreover, they still largely focus their efforts at front end of infrastructures and in the early stage of the design process to determine deliverables of what is to be designed. In other words, "the fuzzy front end is followed by the traditional design process where the resulting ideas for product, service, interface, etc., are developed first into concepts, and then into prototypes that are refined on the basis of the feedback of future users" (Sanders and Stappers 2008).

The maintenance of a traditional designer-client relationship, moved by either social commitment or economical returns, still aligns these practices with the world-view of a specific community of practice or category of people describable according to common needs, qualities or activities. Similarly the maintenance of a traditional project frame makes it difficult to properly evaluate how a user will appropriate design solutions after the project ends and how these will travel in time and space. These conditions, as described by Jones, might prevent us from identifying possible misuses and solutions to those problems where the issue is not the efficiency or sustainability of a single product, company or service provider, but their systemic agency.

Services and experiences

From the beginning of the 90s attention to the role of user centered and co-design practices from management and innovation researches started to increase, setting-up the base for the emergence of a relatively new field of application for design. Empirical evidences of the designers' ability to add value to service and product by catalyzing experiences and cultural changes started to be found (Gilmore and Pine 1999), exposing the potential that design approaches could play in the definition of interaction with new digitally and Internet enabled interfaces and devices. As effect of this interest the designers' attention shifted towards the more 'experiential' and intangible qualities of design, the definition and modeling of systems and new service blueprints.

Exemplary of this new cluster of practices and ideas around which practitioners organized themselves, gaining popularity and attention within the business field are the field of Service, Experience and Interaction design (Kimbell 2009; Kelley 2001, 193-218; Zomerdijk and Voss 2009). Because of the variety of interrelated subjects and the conceptual drift toward business and management that characterize it, to define what this field exactly 'is' result sometime, unclear, and therefore harder to summarize and precisely portray. Nevertheless a short summary of this important body of work is here necessary to later articulate some of contemporary design issues.

Several descriptions of Service Design are available both from in management and in design literature (cf. Verganti 2009; Kimbell 2011a). However this can be generally referred to as an area of expertise concerned with systematically applying design methodologies and principles to the design of services that are able to co-produce value, utility, satisfaction and delight in response to human needs (Holmlid and Evenson, 2008). This definition allows for the exploration of a wide range of methods and applications. Some of the emphasis of service design work is on the design of the physical artifacts and encounters with service personnel with that part of a service at pre-determined touch points and re-definition of back and front-end activities. Researches have explored different methods and tools drawn from ethnography, activity theory and co-design, which have been used to understand users and customers, involving them in the design process, looking at services from an outside in perspective (Sangiorgi and Clark 2004; Holmlid 2009).

The concept of Product Service Systems (PSS) is today also gaining attention (Meroni and Sangiorgi 2011). PSS can be defined as innovation strategy focused on shifting business focus from designing and selling physical products only, to selling a system of products and services or 'enabling platforms' which are jointly capable of fulfilling specific client demands (Manzini and Vezzoli 2003). A strategy that has been increasingly researched as a way to investigate the possible transformative and re-directional role of design as a way to built more sustainable production and consumption models (Manzini, Collina and Evans 2004; Manzini and Jegou 2008); equitable societies and the diffusion of citizen-centered services from the bottom-up (Meroni 2007; Sangiorgi 2011). In particular it contributed to understanding service as the design of socio-technical systems (Morelli 2002).

As Sangiorgi (2011) notice however, with design engaging more and more with complex socio-technical systems for transformational purposes and paradigmatic shift, a change in the core assumptions, philosophy, mission and purpose culture and process of institutions and infrastructures is necessary. Improving service interactions and touch points or helping redefining service values does not necessarily entail transformational impact. There is a need for service designers to develop a more situated embedded and context aware way of understanding services, designing and changing, more conscious of the holistic impacts and consequences of what they make, beyond the specific client and communities of practice they design for (Sangiorgi and Junginger 2015). This observation has in a way several implications for interaction and experience design too. Fields that indeed maintain some differences from Service Design (Holmlid 2007), but at the same time are also constitutive elements of it, considering the many transactions that today are mediated by digital interfaces and electronic devices (cf. Moggridge and Atkinson 2007).

User experience design perspectives suggest that feelings and emotions that accompany our interactions with products and interfaces through which we experience services and interact with infrastructures are replicable, addressable and synthesizable by design (cf. Shedroff 2001). Central for this practice is the idea that technology and its design should be able to suggest and evoke meaningful, engaging, valuable, and aesthetically pleasing experiences. As such experience design deals with topics of artifact intelligibility in expressing its intended use, the clarity of information it conveys, its learnability and appeal; but also with

understanding the interaction possibilities, mediation and expression of digitally enabled devices and their emotional engagement with users (Forlizzi and Battarbee 2004).

These fields of application channeled a lot of interest within design practice and research communities and inspired a large amount of design and human computer interaction (HCI) works. The result was a significant body of knowledge that allowed a better understanding of technological mediation between people and environment and the primarily situated and embodied nature of learning and meaning creation (cf. Dourish 2004). Exemples of this approach to the design of digital artifacts informed by phenomenological and pragmatist philosophies include the research produced by the University of Technology of Eindhoven .

Using a constructive research approach and the creation of mockups and prototypes to explore their solutions with users, the outcome of these explorations offered a rich insight about how to create systems that can be used with one's body instead of cognition (cf. Deckers et al. 2011; Frens 2005). At the same time though, it gave few tools to see how things like social interaction and culture shape conduct. These approaches are still in focus for issues of usability of products at the fringes of infrastructures. These are often front-end interfaces that despite what they can express, still conceal and do not question the back-end dispositions, agency and operations of digital services they enable. Moreover this type of experimentation on expressions and mediation of new devices and technologies is often limited to the within the safe environment of the studio or the lab.

These limitations have been partially solved with the inclusions of more participative, critical and speculative approaches to explore the possible future mediation of technologies and the possible experiences they can provide (Bowen 2010; Odom et al. 2012; Sanders and Stappers 2014). However, they still often maintain research within a controllable environment, focusing on few particular aspects of use and cognition without fully informing "what things do" (Verbeek 2010). This means they do not fully acknowledge the possible meanings, uses and relations that future artifacts and technologies will establish once they will become part the every day life of people, and not necessarily only of their foreseen users.

Rethinking foundations

In recent years a number of design researchers and academics started to re-address questions about what design 'is' and 'does' in relation to its theory and foundations. The re-appropriation of design methods and concept such as "design thinking" by markets and business management theory (Brown 2008) and its broad diffusion, has in fact determined a detachment of design practice from its 'materiality'. A separation that moved the focus of design from being a situated and embodied way of knowing and inquiring for action, to the business model (Kimbell 2011b), and the sustainment of existing production and consumption patterns, through the reproduction of a set of homogenized styles and vogues.

For instance, drawing from Bordieu's social analysis of aesthetics, Cameron Tonkinwise argues that the fossilization of the modernist aesthetic in the design of artifacts and electronic appliances is functional to the corporate's sustainment by limiting the possibility to identify new styles. Modernist forms have been taken for granted and replicated in a variety of practical styles of taste regimes[12]. From 'form follows function', he argues, we passed to 'functionality follows the taste practices of the target market'. Aesthetics had become the means through which to persuade someone to do something, thus there emerged a new interest towards users and their experiences. This was the beginning of a way of seeing design as a problem based activity functional to business management purposes and a push to market strategies (Tonkinwise 2011).

Style here does not have to be understood only as 'aesthetic qualities' of something, but also the possible 'organizations and practices' that different socio-material configurations allow (Tonkinwise 2011). Thus, the artifact is de-politicized: what needs to be designed is already largely defined *a priori* by business

12 As the Italian architect and designer Andrea Branzi (1988, 41-46) argues, in a later reflection about the HfG of Ulm, the school largely contributed to define contemporary industrial aesthetics. This was the synthesis of a new rationality aimed at the neutralization of the expressive qualities of the object: an aseptic and minimalist language intended to rescue people from the industrial object, its visual intrusiveness and mechanical arrogance, transforming it in to a gray instrument enclosed into a case 'of industrial perfection'. "This style has triumphed outside the methods of design and has even determined the appearance of today electronic apparatus, where the object is truly something that has no formal existence, since its design consists in the service and software that it manages to provide" (1988, 42). The values and social ideals driving the work of Ulm were still largely modernist. With the passing of time the design approaches and aesthetics defined in the school remained. What has changed is the alignment of design practice and aesthetics with the culture of consumerism, substituting the public and social interest that guided the modernist technological and infrastructural development with the private interests of the companies' and brands' values.

and innovation groups according to economical and technical requirements and in-house competences and skills. What remains for designers to do is to inform what aesthetic qualities fit better the target group, using the right language to express the functionality and intended use of the object.

As Redström (2006) argues, there are some controversial aspects in the shift from shaping 'style' to shaping the perception of objects. The separation and concealment of everything that concern the functionalities of the technical apparatus, such as the technology within a device and that support its production and operations, from the action and competence of the designer determined a change in the focus of design that is now about make users 'fit' within the envisioned plans and interaction of products and their business models. A quite controversial practice if we think that it's quite hard - and perhaps also ambitious - to anticipate and determine the infinite ways and contexts in how technologies and product will be actually used in every life and by who.

As Ihde notice in his phenomenological account of technology there is difference between design intention and actual use "only sometimes are technologies actually used for the purposes and the specified ways for which they were designed. Two interesting examples of this have been the typewriter and the phone. Both were originally intended as helps for impaired persons, … what was to become their extremely important set of social uses ultimately entailed little of the original designer intent" (Ihde 1993, 116). Thus, by enforcing a certain solution and use, black-boxing the technical system behind its operations, we are actually limiting our ability to explore the unexpected practices that might develop around an artifact and the possibilities to explore the possible negative consequences of its introduction.

If design is the process by which we devise courses of action aimed at changing existing an solution into preferable ones (Simon 1996), we might start asking ourselves, if the current way of designing, manufacturing and applying technology do represent the best alternative we have. The progressive 'drift' of design as a mean to prescribe use a-priori represent a constraint to our ability to articulate and address postindustrial issues. Mockups and design games are now used to understand user preferences. Concepts are finally developed and visualized through system maps, interactions storyboards and service blue prints. Tools largely used in the field of interaction and service design to describe qualities of the envisioned systems.

Despite their user centeredness and participatory nature, these practices and their materializations however are still largely descriptions of 'what it ought to be', The outcome of a rational problem solving process, as Herbert Simon defines it in the Science of the Artificial (1996), that starts from the decomposition of a complex, ill-defined problem, and develops into a set of simpler well defined ones addressable by design. If this type of approach proved to be valuable in the past allowing practitioners to ground their design on facts, today the problems we need to deal with in relation to increasing impact that artificial systems have on the environment and human activities require a different one. In a world where multiple and contradictory descriptions and explanations of the same phenomena coexist, decisions about what is preferable cannot be generalized, but might instead require us to go back to theory, and re-think the basic foundations of design research and practice (Friedman 2008).

What is emerging is the need of a practice more aware of what it does regarding the practices it hinders and those it supports (Fry 2009, 193). Being an industrial practice design is co-responsible of several issues concerning sustainability, agency, scale and controversies mentioned in the previous chapters of this section. These systemic problems are not addressable through rational problem solving approaches and their 'simplifications' (cf. Jones 1992) or by increasing the sustainability and efficient single systems of products and services (Fry 2009, 54; cf. Hawken, Lovins and Lovins 2013). The resolution of present controversies requires a higher understanding of the context, its underlying infrastructures, agencies and power relations. Awareness that can be achieved only through a prolonged involvement of all those that will be affected by a future design configuration to understand how to safely attune it to their context of use and give it a meaningful place in their life.

The limits of user centeredness, a case study: Satin

In the first two years of my PhD, I had the chance to take part in an EU funded research project aimed at exploring possibilities for interaction of people with the Internet of Things as environments. The result of this project is Satin, a mobile application builder that enables end-users without programming skills to create their own apps, aggregating and seamlessly handling data and programming interfaces (API) from different services in a user-friendly manner. The case study illustrates that apart from following user-centeredness, designers should also consider the constraints and influences of the infrastructures within which they operate. When designing innovative systems such as Satin, the context and paradigms that one works from inevitably affect the solution space in which the final designs and products exist. This requires designers to work not only on the final product's usability and experience of use, but also on the foundations and underlying infrastructures that rules that specific design space where this will be introduced (Davoli and Kuenen 2013).

The project was divided between closely collaborating and partially overlapping project teams: Project Management, Core Technology, Business Development and Design. Within this framework, the goals for the design team were to develop the touch point between users and the Satin platform and its back-end compiler: an easy to extend markup language that enables the assembly of various data sources and compilation of executable for various platforms. Compared to other existing programming tools for beginners, the aim of the Satin project was not to educate people to become programmers but to empower people towards making sense and use of the digitally enabled world around us. Thus its research and design particularly focused on understanding what the best "language" for such a tool might be and how the interaction with it should take place and how to engage with it, avoiding the limits and barriers generated by current programming languages.

The team adopted a user-centered approach. In an iterative workshop process with experts as well as non-experts, different interaction metaphors and paradigms for the editor were collaboratively explored. The purpose of these studies was to determine how people could understand, manage and aggregate information and data available from Internet services and open data databases into customized services that are relevant and meaningful to them. These iterations

Video snapshots of a user interface evaluation workshop: participants exploring one of the possible interaction styles for the Satin editor through physical mockups.

revealed that the difference between experts and non-experts lies in having a detailed understanding of how different elements and information need to be connected and combined in order to result in the desired overall functionality. These observations resulted in the development of a possible concept for an 'Agent Based' editor.

The general idea behind this concept was to enable people to simply find data stream in their environment, collect them and use them for their own purposes. Once icons representative of the different data streams are dropped into the programming interface, these different agents could express their awareness of each other's presence and their functional interactions. Once dropped-in, the programming interface people could explore how they can interact among each other by looking at how the different icons behave, pulling or pushing information without the need to set parameters or relations between them. The agent-based paradigm was first developed into a low-fi prototype. Magnets and colored rings of paper that represented the kinds of information an agent can push into or pull from the environment were then placed in position, and used to engage non-experts in a conversation about this particular type of interaction. These interfaces have been then further developed into a functional prototype and used for further user tests.

The main results from these studies was that, although people could generally understand how to use the graphical user interface and set up interactions between the push and pull properties of agents, they found it hard to understand what they could make with it. How to use the agent-based programming interface was well understood by the test participants and they could easily explain rationally what they were doing and what results they were expecting when setting up connections between components representing different information sources. Nevertheless, what they found very difficult to understand is why or what for. They could not 'get' the ultimate aim of using the Satin editor. They were unable to see why they should make one app instead of buy or download an existing one provided by a company or an expert programmer.

People found it very difficult to project themselves into a future where information is retrievable from any artifact or web service at any time. Therefore, they were not able to come out with solutions tailored on their own specific needs and experiences, nor did they understand why they should participate in the co-creation of applications with companies and third parties. Most of the non-experts in our tests would not consider spending time composing their own

functionality without seeing a clear advantage in that activity itself. Reflecting on the user testing, we realized that there was a gap between what is possible to enable through technology and how to develop and apply it in order for people to make sense of and with it. We were trying to support people to generate functionality without an application context or an experience of what that future could be. As expert-programmers do, we were approaching this design from the abstract to the concrete, whereas people understand the world the other way around. While experts are comfortable in creating objectives in an unconstrained space, non-experts often need a space of application and curation, of context-relevant content to generate functionality.

Another important aspect to point out is the mismatch between the concepts and foundations behind the Satin project and the foundations required by its deliverables. While the project goals and requirements where charged with innovative and disruptive intentions, the set of broader systems, such as technology, information infrastructure, work organization and structure of the project, inevitably affected our final results, making us approach the problem through a lens of established frameworks and practices. This led us on to focusing on deliverables and functionalities, keeping users, spaces and technology as separated actors. In this process and environment, the technological opportunism inevitably prevailed, progressively pushing design to create an interface that efficiently links users to technology. Finally we did not take into consideration the current formats of information and how it is made available through Internet services, i.e. impersonal, available anytime and anywhere. Paradigm that is ill suited for the requirements of the new tool and caused of the Satin interface to be irrelevant for users.

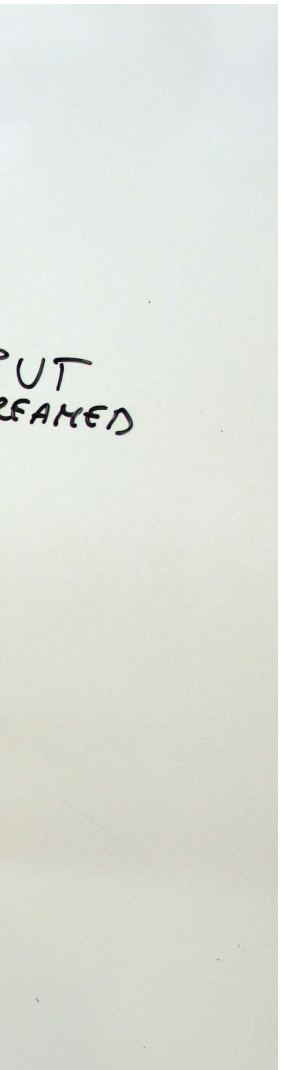
As it emerged from our tests, people experience an indirect need of the tools, but a direct need of fruition and content that those tools may provide access to. The usability and usefulness of a tool is not about its instrumental functionality, but about the design and construction of things that can become meaningful parts of the environment and of our lives, its places, practices and experiences. The inability of the project organization to provide the necessary environment to fully explore the possibilities behind the agent base concept to provide this type of meaning, made the project management to turn towards more traditional user programming interface styles[13].

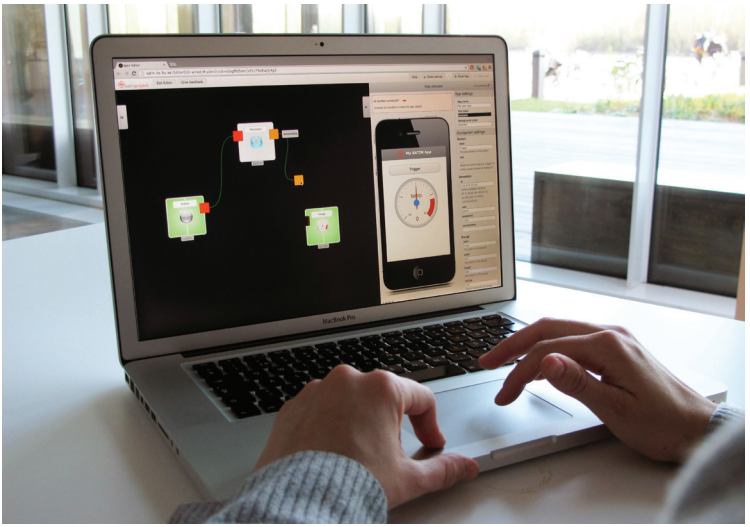
13 Both the agent base editor and its alternative are available for test at: http://www.satinproject.eu/

Above: agent based interface physical mock-up.

Top right: the final, functional, Satin editor interface based on a more traditional 'connect and set parameters' interaction style.

Bottom right: the speculative design of a mobile agent-based interface to explore contextual digital content and gather data from space.


UT
EAMED



The unsuccessful example of Satin in providing meaningful possibilities for interaction to its users, emphasizes the need for development of a new prospective and way of working on the design of interactive systems. This should be informed by a holistic stance based on contextual day-to-day experience and behavior as a guiding principle for technological development which can very unlikely fit within established ways of designing and developing these technologies. These issues and themes are now largely explored and debated in the design community and will be summarized in the next and final chapter of this first section.

Postindustrial practices

In recent years a number of designers and researchers started to reconsider their role and responsibility in relation to mass production, social, environmental and technological implication of their practice. Postindustrial debates and explorations started to grow, researching and expanding the design toolkit and expertise beyond traditional 'industrial' mindsets and approaches. The result of these inquires is a set of postindustrial practices where design forms and expressions are more explicitly used as the means to question and articulate present controversies, rather than to simply provide end-results and identify functionalities. Within these practices critical, speculative and participatory approaches are merging and cross breeding, providing the necessary materials to allow experts and non-experts to share experiences and collaboratively explore more sustainable and inclusive solutions, to investigate present situations and investigate the political and social implications of future design configurations.

This chapter provides a summary of some of these material inquiries, their theoretical stances, methodological contaminations and critical views. The purpose of this review is to establish what tools and approaches a transitional practice for the design of postindustrial infrastructures needs to include. In particular, these theoretical and methodological stances can help designers to identify how to responsibly and ethically model systems and socio-material configurations, curating their introduction in their future contexts of use.

A redirective practice

A first fundamental common denominator that these perspectives recognize as a substantial challenge for design research and practice is that a shift toward more socially and environmentally sustainable forms of production is becoming a pressing necessity more than an option. As Fry (2009) argues, the existing economic and production paradigm has exhausted its modernist social incentive, revealing clear limitations in its ability to create the global, economic and political conditions to equally provide wealth and "sustainment".

The second one common factor is the shared critical stance towards a dominant and homogenizing idea of 'progress' prescribed by matters of facts, scientific

evidence and market logic that characterize much of technological development imposed by Silicon Valley's companies and other major IT and financial market players. A vision of the future that using the words of Bruno Latour in his 'Attempt at a Compositionist Manifesto', "never actually looked toward the future but always to the past" (Latour 2010, 486). Modernist utopias of technological salvation will hide more dangers and new forms of violence if we do not start to think about what kind of future we want and how to achieve it, instead of building it from the base of questionable description and analysis of present situations.

According to Latour:

> What makes the times we are living in so interesting (. . .) is that we are progressively discovering that, just at the time when people are despairing at realizing that they might, in the end, have "no future," we suddenly have many *prospects*. Yet they are so utterly different from what we imagined while fleeing ahead looking backwards that we might cast them only as so many fragile illusions. Or find them even more terrifying than what we were trying to escape from. Faced with those new prospects, the first reaction is to do nothing. There is a strong, ever so modernist, temptation to exclaim: "Let's flee as before and have our past future back!" instead of saying: "Let's stop fleeing, break for good with our future, turn our back, finally, to our past, and explore our new prospects, what lies ahead, the fate of things to come. (2010, 486)

The necessity for 're-direction' from the unsustainable future we are currently set on is at the center of Tony Fry's argument regarding the 'futuring' role of design (2009). To achieve sustainability — and therefore hope for a future — a radical change within the current paradigm, its culture and infrastructures, it's mandatory. He therefore suggests that we should interpret Design as a redirective practice, aimed at questioning future possibilities rather than problem solving. A practice able to break existing divisions of knowledge, allowing different experts from analytical domains to converge and discuss future possibilities rather than the status quo of things:

As Fry argues:

> Disciplinary thinking, by its very nature, is exclusory, and thus has limited ability to comprehend and engage the relational complexity of in-sustainability, and the creation of sustainment. But the suggestion is

> not that we dispense with disciplines but rather they need bridging by a meta discipline that facilitates an exchange of knowledge and dialogue based on a common language of engagement, while also amassing collective knowledge in their own right. This thinking is not the same as either the synthesis of 'multi-disciplines' or the dialogue of 'inter-disciplines'. Redirective practice names the meta-discipline. What redirective practice enables is a practical transformation of knowledge in action.
> (Fry 2009, 55)

Inquiring into the future and toward change for the 'common good' obviously entails the designer engagement with topics such as ethics and politics. Commitment does not "unrealistically suggest that all commercial consideration are abandoned but rather they are strategically and economically repositioned under the imperative of working toward gaining sustain-ability" (Fry 2009, 47). Thus the necessity to develop and experiment with tools and processes enable engagement with publics and matters of public concern and generate concrete and viable possibilities for transition towards more sustainable economies for businesses and companies.

An important contribution towards a definition of more sustainable, equal and citizens centered ways to produce, consume and access to services and resources, is the seminal research work and practice of Ezio Manzini and his collaborators (Manzini 2015). As his work illustrates, in a world where 'everybody design', social and bottom up innovations are providing alternative and sustainable ways for working, making and collaborating, as well as an example of what the future of production might look like. Designers can support and curate the implementation and diffusion of these systems of products and services through their skills in guiding and facilitating the creation and exploration of alternative stakeholders, interactions and systems configurations. Sustainable Scenario creation for instance represents an important tool to visualize a future possibility, interrogates it and thinks how to possibly implement it (cf. Manzini and Jegou 2003; Jegou and Ezio Manzini, 2008). However, this distributed design capacity needs to be cultivated, requiring designers to not only think how to conceive these alternative but also to overcome some of the scalability and diffusion constraints exerted by the industrial regime within which they operate.

Design as infrastructuring

A fundamental question in the age of information, 'code' and digital manufacturing is how new designs can travel, be replicated and re-appropriated locally without altering their nature, scale and original intentions. In his "Manifesto for postindustrial design", Jamer Hunt (2005), described how one of the issues in the postindustrial era is the definition of the 'DNA' — the essence of a product a service or a technological application. Task that will require designer to change the way they operate "working with new and unfamiliar tools in strange and unlikely places" to understand how these material can travel, be manipulated, adapted and replicated without loosing their original intent and purpose.

Postindustrial designers' Hunt argues,

> Will no longer dictate form from the system's center and then foist their wares upon a passive marketplace. Instead, more and more design will be a code and a set of parameters. That code will then be let loose in an electronic ecosystem so that it can be manipulated, changed, improved, hacked, and produced in multiple variations in myriad places. These new processes of design are more biological than mechanical. They are flexible, adaptable, sustainable, and self-organizing. The "design" will gain energy and vitality through this distribution and circulation, just as genes do. Code, too, has its own characteristics, traits, patterns, and needs. It has metabolism. It survives through modified loops of input, stimulation, feedback, circulation, and change. Sprawling networks of data that are ubiquitous, immediate, and infinite will amplify and distribute that code. In this way, code becomes dynamic; it is alive to its environment. (Hunt 2005)

If we look at social networks, digitally mediated and collaborative services, 3D printed objects or the software running beneath autonomous vehicles, we realize that the reach and the scope of design goes well beyond one single community and could travel in multiple and very diverse contexts globally (Ehn 2008). Bottom up innovation, artifacts and front-end solutions and their agency in the world have become an infrastructural problem. This cyborgian and blurred interdependence of people and things introduces a new set of practical and political challenges for design and existing participatory and user-centered practices (cf. Haraway 1994). It is therefore necessary to consider that "as the information systems of the world expand and flow in to each other, and more kinds of

people use them for more different things, it becomes harder to hold to pure or universal ideas about representation and information" (Bowker & Star 2000, 301-302).

As Pelle Ehn suggests in his paper "Participation in Design Things" (2008), with the design scope becoming that of "infrastructuring", new design processes and methods to allow designers to cope with a plurality of interpretations and variety perspectives are becoming necessary. With the change in the scale and reach of design solutions and their potential impact, there is also an increasing need to understand how these might travel and be appropriated by different people (of varying education, class etc…) across time, locations and spaces. Similarly there is a need to develop a facility and negotiate with the installed base of networks and conventions of practice that characterize different contexts, and that, with their agency, define possibilities for action and change (Star and Ruhleder 1996).

Mediation, use and aesthetics

A considerable body of work is developing around the themes of agency, technological mediation (Verbeek 2011) and definition of 'use through use' (Redström 2008). At the center of this discussion is the notion that objects and technological configurations play a mediating role in our lives and they co-shape with us our relationships to the world. Thus, in order "to design and evaluate a design with regard to presence of designed things in our everyday life, we are faced with the problem of relating design and evaluation to existential definitions of things, that is, to their particular existence in someone's lifeworld" (Hallnäs and Redström 2002, 111).

Drawing on the work of Latour, Akrich and Ihde, Verbeek describes how technology can both invite and inhibit human interaction as it can amplify and reduce human perception.

> Designers define users, in terms of their taste, competence, motives, aspirations, and political prejudices. Such definitions then are "inscribed" into the technical contents of the object. Designers anticipate the use people will make of the product they are designing and, because of that, products contain implicit "manuals." Things co-shape the use that is made of them: they define relations between people, and distribute responsibilities between people and things. Technologies create a framework for

> action even though it is never certain that they will be used in the way the designers intended. (Verbeek and Kockelkoren 1998, 34)

Thus, objects own a certain 'intentionality'[14] that extend beyond the purpose and function than its designer gave it. These active and mediating roles of technology in the way people perceive and act in the world open up a series of ethical questions for designers about their ability to anticipate the possible consequences of their work. This is according to how, "when technologies are inherently moral entities, this implies that designers are doing 'ethics by other means': they materialize morality. Usually this happens in an implicit way. The question, therefore, is how considerations regarding the mediating role of technology will eventually play in society could be integrated in the design process. (Verbeek 2006, 369)

Mediation is not only the result of the activities of the designer, but it also depends from the user who interpret and appropriate technologies and on the technologies themselves, which can evoke emergent forms of mediation. "To cope with this complexity", Verbeek argues "designers should try to establish a connection between the context of design and the context of use. Designers could try to formulate product specifications not only on the basis of the desired functionality of the product but also on the basis of an informed prediction of its future mediating role and a moral assessment of this role" (Verbeek 2006, 372).

Along these lines, Redström (2006) suggests a move from a design processes aimed at the definition of 'use before use' to a definition of 'use through use'; shifting from design processes aimed at testing and trying out 'use' in advance of actual use, to one more open and undetermined one, where prototypes and their use co-evolve through their everyday life interaction with people. According to Redström, design processes have always been concerned with the definition of use through mockups and prototypes. However, there are substantial differences in how they open up for acts of defining use.

User-centered methods for instance aim at anticipating eventual use during the design process by engaging or producing information about people who are considered to be potential future users. User tests and experience prototyping

14 Intentionality is a philosophical term that refers to "the power of minds to be about, to represent, or to stand for, things, properties and states of affairs". For more comprehensive understanding of its meaning and etymology see Stanford Encyclopedia of Philosophy, Intentionality. http://plato.stanford.edu/entries/intentionality/

techniques (cf. Buchenau and Suri 2000) are used to understand how a given design is interpreted in order make sure its intended use (i.e. the design purpose and functionality established *a priori*) is easy to understand. Participatory design represents a step further, since it allows different orientations and discrepancies in the definition of use by allowing participant to co-define it and to collaboratively understand how to evolve artifacts and services towards their final configuration. Thus, in participatory practices the definition of use and the qualities of the object of design are more open and less defined than in user-centered ones. Nevertheless they are still aimed at anticipating 'use before use'. The designer still gives away responsibility about what can happen in the context after the design project is ended while its focus is still on projects supporting identifiable users.

According to Redström the third necessary step towards a more holistic and informed design process would be therefore to open it up for acts of defining 'use through use' by extending it beyond the traditional project time. This means to define the qualities of new design and configuration 'through' their interaction with the future context of use. Prototypes and mockups that are representative of future solutions could be made present in people's every day, exposing it to the variety of events and actors that inhabits it, allowing a better understanding of their possible agency and mediations (Redström 2008).

Examples of practices where this happens already exist. For instance, some of the work from the Interaction Research Studio at Goldsmith is aimed at understanding people's different interpretations of their interactive systems and artifacts through extended interaction over time and in their intended context of use. As Sengers and Gaver (2006) suggested, designs might need to be evaluated among a range of possibilities that can be explored and that may more fully address the complexity, dynamics and interplay of user, system, and designer interpretation. Other examples of use of devices in real life settings are also available in Routarinne's investigation of 'domestication' as a means to understanding uses and relationship of artifacts in everyday context of use (Routarinne and Redstöm 2007). In the design of interactive systems instead, 'meta-design' approaches allow diverse non-expert users to modify and evolve software and digital media interfaces according to their situated needs and after project time, through ad hoc toolkits and supporting environment (Fischer and Scharff 2000; Giaccardi and Fischer 2008).

Also because of these experiences, today we can frame a new set of theoretical and practical questions about what kind of open and evolutionary approaches

such as meta-design could be developed to operate outside digital environments. There is in fact a need to provide designers with the appropriate tools to more consciously explore the ethics of the designs they suggests: the practices and behaviors they might enable and support and those they might limit, and how they do that (in relation to sustainability for example). For instance, with the shift from 'design for use' to design as definition of 'use through use' we seems to be confronted with the need to develop a series of design-games in sequence, engaging with an uncontrollable plurality of participants and events in time, through which to evolve prototypes in time into final solutions (Ehn 2008).

Another set of questions might concern instead the level 'interpretative flexibility' (cf. Bijker 1987), definition and politics of representation of mockups and prototypes — how undetermined their features and functionalities are and what they convey — and how these can constrain or allow openness in the participants' interpretations (Redström 2006; Sengers and Gaver 2006; Tonkinwise 2011). A possible a way to navigate this heterogeneity is, as suggested by Tonkinswise, by mastering the politics of aesthetics and 'practice styles' they enable.

Drawing from Bourdieu and Flores, Tonkinwise (2011, 538) suggests that, "style is a translator of people's structured choices into action propensities". People from different social and cultural extractions may like the same thing, but for very different reasons. This aesthetic judgment though, is not only informing us about the aspect of things and about someone's taste, but it also provides an insight into what he or she can do, or could be helped or persuaded to do. The design practice has an expertise in discerning people's taste regimes, knowledge that could be used to explore how different — e.g. more sustainable and democratic — practices can be established.

According to Flores (2000), "When people change their practices in meaningful ways, they do so on the basis of the style they already have. Style acts as the basis on which practices are conserved and also the basis on which new practices are developed." (as quoted in Tonkinwise 2011). Thus, the 'style' of mockups and design explorations (the different qualities and practices that a particular design enables) becomes the instrument to explore and compose alternative design configurations. On one hand it is the variable through which to experiment alternatives, on the other hand it becomes the pivotal axis — the point of stability in the instability of the context, through which to navigate its heterogeneity, and the variety of practices, purposes and uses that a field site might influence or restrict.

Examples of research practices addressing such issues related to technological mediation, and definition of use through use 'through aesthetic' also start to become available. For instance Pierce's 'counter-functional camera' design and its brochures play with different expressive and aesthetic qualities and interactions styles, mixing qualities and features of consumer products with those of hand crafted and artistic productions. By inhibiting or removing common or expected features of a technology, the photo camera becomes a means to explore and speculate about alternative uses and practices it can allow. Features that from a market and usability perspective would be commonly interpreted as 'negative', here contribute to the subjective experience of something positively enabling, opening up this device for a diversity of interpretations and appropriations (Pierce and Paulos 2015).

Due to its critical attitude towards prevalent notions of design, usability and aesthetic, the camera project legitimately belongs to a prolific field of design research, operating at the intersection between technology and aesthetics, engineering and politics, which is more extensively illustrated in the following section. This is a field now rapidly evolving, merging aesthetic qualities and techniques of critical and speculative practices with more participative and politically engaged methods and instances.

Publics, speculations and adversarial things

The rapid scientific and technological advancement and the pervasive penetration of the artificial in many spheres of human life, from artificial intelligence to genetic manipulation, is today a source of a series of questions and concerns regarding their implications on society and its institutions. New technologies always open up new opportunities and possibilities for alternative infrastructural organizations and different way to supply end results. Nevertheless, their implementation its often a potential source of discrimination and new kinds of social conflict. In particular they raise questions about who has the right to determine their final configurations and applications, and how these are defined.

As previously mentioned, prevalent planning and design practices tend to conceal the decision making and dispositions that guide their developments, often endorsing the private interests of lobbies and corporations over the public ones. These differences in economical power and access to information exclude citizens from the possibility to judge and express their consensus or disagree-

ment regarding decision that will affect their everyday life. Thus a lack of transparency is partially also responsible for the inability of existing decision making frameworks and development processes to articulate and anticipate the possible coercions and rebound effects of new designs and technologies before they actually manifest themselves in society.

Since the late 90s a growing number of designers and researchers started to address how artifacts and products of design can shape and contribute to public discourse and civic life. In these practices design is not interpreted as a problem solving activity but as a mean to critically inquire into sensitive matters of public concern characterized by heterogeneity, disagreement and plurality of interpretations, challenging the inherent optimism and homogenized mass consumption aesthetic of design (DiSalvo 2012; Dunne and Raby 2013). A first possible example of a way in which design can contribute to the construction of publics is by 'projecting' future possibilities and representing possible consequences associated with an issue or action, such as in critical design practices (DiSalvo 2009).

Anthony Dunne and Fiona Raby coined the term 'critical design' in the mid-nineties during their work in the Computer Related Design Research studio at the Royal College of Arts. This program and projects portfolio largely developed as reaction to their growing concerns about the uncritical drive behind and commercial opportunism of design and a belief that technology alone is capable of solving any problem. According to their definition "Critical Design uses speculative design proposals to challenge narrow assumption, preconceptions, and givens about the role products play in everyday life (Dunne and Raby 2013, 34).

Critical does not mean negative, but ways to convey a wishful thinking. Critical designs materialize what could be, but at the same time they offer alternatives that highlights weaknesses and issues within the existing normality and dominant positivist rhetoric of fate in technology (Dunne and Raby 2013, 34-36). For instance, in the 'Hertzian Tales', Dunne and Raby were exploring the implication of increasing numbers of digital and electronic devices. For instance by jacking-in to the frequency of baby monitors they invited a reflection about hackability of wireless and electronic devices and questioned the new private-public relationship they establish (Dunne 2008, 137).

More recent work in the field of speculative and critical design addresses future uses and implication of biotechnology challenging the "one future" that technol-

ogy companies provide or rather impose upon society. For instance in the exhibition "Is this Your Future?" Dunne & Raby produced a set of unconventional and destabilizing scenarios about the future's energy production and the role of individuals would play in this activity, thus exposing some of the consequences of pursuing current dominant themes in the science and technology of energy production (Dunne and Raby 2001).

As Dunne and Raby (2013) argue, thinking about the future is usually concerned with predicting or forecasting it:

> Sometimes it is about new trends and identifying weak signals that can be extrapolated into the near future, but it is always about trying to pin the future down. This is something we are absolutely not interested in; when it comes to technology, future predictions have been proven wrong again and again. In our view this is a pointless activity. What we are interested in, though, is the idea of possible futures and using them as tools to better understand the present and to discuss the kind of future people want, and, of course, ones people do not want. (2)

These futures usually take the form of provocative and simplified, fictional scenarios driven by hypothetical "what if questions" and are intended to open up spaces for debate and discussion. "Their fictional nature requires viewers to suspend their disbelief and allow their imagination to wander to momentarily forget how things are now and wonder how things could be" (Dunne and Raby 2013, 3). Thus designers produce the necessary material to experience and to interface with a possibility and to understand what it could mean for different people, compelling the observer to reconsider how the present is futuring and how we may still have a chance to reconfigure that future potentiality (Hunt 2011).

Critical practices do not necessarily include participation — the 'consumption' of most critical and speculative design projects is in fact happening at a personal and cognitive level accessing the artifact through exhibitions and images — however their general backdrop is, implicitly, in participation and social action. For instance, speculative form and design fictions are starting to be integrated in co-design works (Sanders and Stappers 2014). Similarly, in the past years several projects have explored possibilities for using participatory tools and methods as a means to allow heterogeneous groups of citizens to engage with local prob-

lems allowing them to construct their own rationale regarding matters of public concern.

Design forms and materials for example are employed as tactics to 'trace' and 'materialize' origins and consequences of issues that would be otherwise impossible to perceive or relate to (DiSalvo 2009). In the project "Zapped" for instance design materials were used to detail, communicate and make known the networks of materials, actions and cultural factors that shape and frame issues regarding Radio Frequency Identification (RFID) technologies, in ways that foster knowledge through engagement. Similarly, several examples of participatory sensing approaches (Burke et al. 2006) in a verity of fields are available ranging from monitoring pollution, to local gardening and food production (DiSalvo et al. 2012; Kuznetsov and Paulos 2010a).

What these projects have in common is that they all use design mockups and sensor probes as ways to engage citizens in both discussing and producing data about a certain topic. In particular, they show how design objects do politics and can be used to engage citizens with different cultural backgrounds to collaboratively explore possibilities through collective endeavors and discussions. However the problematic situation that gives rise to a public do not need to be political, but they can be formed around a lived experience (DiSalvo et al. 2014). Thus, they do not necessarily take a critical stance or attempt to shape beliefs and courses of actions toward any specific direction. As such sometime they could be still interpreted as problem solving activities often focusing on reconfiguring interactions at the front-end of infrastructures without questioning or challenging structures and power relations that influence contemporary society and that frame the possibilities for design action.

In his book "Adversarial Design" (2012) Carl DiSalvo, drawing on Mouffes's Theory of Agonism (2000) addresses the distinction between Design for Politics and Political design, providing a means to better analyze the scope of these projects. Agonism is a political theory that emphasizes the potentially positive aspects of certain forms of conflict as constitutive element of democracy and progress if well channeled and cultivated. Through a series of examples DiSalvo shows how design can express agonism through its expressions, as ways to articulate the experiential consequences of socio-material configurations and the issues they raise.

DiSalvo argues that while 'design for Politics' describe the set of means and mechanism that enable governing within the boundaries of existing laws, beliefs and values, 'political design' entails dissensus from the current paradigm. Accordingly, "most of contemporary design projects that purport to support democracy do so in the realm of politics and not the political. (. . .) Design for politics most often works to improve access to information or to improve access to various forms of ordered expressions and actions" (DiSalvo 2012, 8). Political design instead challenges existing conditions and structures.

To support his argument, in his book DiSalvo identifies a series of projects and tactics that not only allow for participation and collective exploration of matters of concern, but also instantiates a possibility for another ordering of existing socio-technical configurations that allow different possible ways of acting in the world. These projects do so by providing the materials for a shift towards actions that challenge the present conditions and enable new antagonizing practices and form of political activism, providing believable models for future actions and conditions (DiSalvo 2012).

An example of this participation and collective exploration is Mark Shepard's Sentient City Survival Kit, which provides products to protect oneself from the increasing intrusiveness of tracking technologies (Shepard 2009). The CCD-Me Not is an umbrella studded with infrared LEDs visible only to CCTV cameras that allow its user to protect oneself from tracking algorithms used in modern surveillance system and advertisement. In a similar way the artist and engineer Natalie Jerimijenko investigates the potentials for public engagement with environmental matters by reimagining the relationships between citizens, technology and the environment.

In the 'Environmental Health Clinic' for example (Jeremijenko n.d.), she invites citizens to collaboratively create and engage with a set of public installations addressing local problems that while challenging the existent provide a possible solution to these matters. For instance in "No Park," car parking lots were substituted with micro engineered green spaces that while still providing parking lots for emergency vehicles, creates a new symbiotic relationship with the city, cleaning up and filtering water from pollutants and providing another set of advantages to citizens otherwise hard to communicate.

In their simplicity these projects question and reframe notions of expertise in technology development and use through the crafting of media events and

public performances, provide an example of how to possibly engage a broad and diverse audience in a discussion about a matter of public concern. Thanks to their critical attitude towards established practices and their 'rightness', these projects provide a foundation for examining and reconstructing political conditions as they are and for imagining the political conditions as they might be. Similar critical attitudes toward prevalent technology-development and decision-making policies also characterize much of the participatory work and activities conducted in Malmö at Medea Living Lab.

Through its activities[15] Medea Living Lab challenges the dominant way of thinking about innovation as promoted by large Silicon Valley's IT corporations; their ideas of unaltered market logics which privilege particular crowds and particular places as center of innovation and their neo-colonizing activities (Suchman 2008; Björgvinsson, Ehn and Hillgren 2010; Ehn, Nilsson and Topgaard 2014). In particular it questions liberal market notions of democratized innovation and the use participatory and open innovation practices by companies as means to 'harvest' users and consumer innovation into safe and profitable mass-market products.

In antithesis to this view, Medea's members present an idea of innovation based on diversity, inclusiveness, distributed production and creativity. They explain this idea according to how, "we share the ideal of democratizing innovation, but we do so beyond the liberal idea of the free individual that can become anything he want thus acknowledging that questions of democracy also are power struggles about distribution of resources and rights in which the voices and values of more peripheral but important groups may remain unheard and may not be taken in to account" (Ehn, Nilsson and Topgaard 2014, 3).

Meadea Living Lab deals with a range of social and entrepreneurial activities, focusing on social innovation, distributed manufacturing and open commons. What makes it particularly interesting though, is how its researchers engage locally through situated and fieldwork activities with their surroundings, which is a multiethnic neighborhood considered to be socially problematic. Conflicts, controversies, and possibilities for innovation are collaboratively explored through long-term commitment projects and through an 'infrastructuring' process aimed at waving new relations between communities, local institutions,

15 For an overview of the Lab's projects see Ehn, Pelle, Elisabet M. Nilsson, and Richard Topgaard. *Making Futures: Marginal Notes on Innovation, Design, and Democracy*. Cambridge MA: MIT Press. 2014.

companies. As Ehn Nilsson and Topgaard (2014) argue, "these thinging and infrastructuring activities do not presuppose consensus among the participating stakeholders but are inspired by the idea of agonistic democracy, aiming to find ways to turn antagonistic relations into adversarial productive and more democratic interactions and outcomes" (9).

Evolving practices

As it emerged from their description there is 'a thread' that connects the postindustrial practices illustrated in this chapter to participatory design and a possible trajectory for future research developments has already been partially traced. Politically, participatory design started as local knowledge production, typically through collaborative prototyping in the struggles and social inequities about the design, and through implementation and use of information technologies. Today's postindustrial approaches are moved by the same democratic values, but in a new context. They explore and experiment new ways to deal with the new socio-technical conditions and counteract the several coercions that established 'industrial habits' in the way we conceive technology and development contribute to generate.

Design seems to already largely own the necessary knowledge and competences to materialize and investigate alternatives futures as well as the necessary theoretical and methodological foundations to re-direct its practices. Speculative designs and sustainable scenarios can visualize possibilities for more sustainable futures and equal societies. These can be materialized and used in the design process as dialogical material to enable discussion and participation and to understand how to curate the introduction and development of new ideas. Finally, notions of 'mediation' and definition of 'use through use' provide designers with a methodological approach to question and anticipate the consequence of the introduction of a future technology or design configurations. Approaches that invite designers to move the design activities from the studio to the field as a way to prototype and rehearse concepts in situ, can open up the design process to a variety of actors, participants through happenings and public performances.

These methods and perspectives undoubtedly provide a substantial contribution to the definition of what a new transitional practice can be, by informing how to responsibly and ethically design new socio-material configurations and attune their introduction within their contexts. As we will see in the second part of this

dissertation, however, beside their fundamental theoretical and methodological inputs, the scope and reach of these practices alone might be not be sufficient to enable re-direction and paradigm shift.

As illustrated by Fry, one of today's challenge for design is not only to evolve and critique its own practice, by articulating new ways to address new human, societal and technological needs but also to understand how to influence and initiate change in the industrial systems that limits the scope of its action. Thus, what seems to be a logic step to evolve the discipline and it practice is to explore tactics and strategies to enable this re-direction. This means to explore how to produce the necessary materials and arguments to enable change and to provide these new ways of thinking and doing design, that are so attentive to openness, diversity and sustainability, with the proper foundations to prosper.

II. TRANSTRUCTURES

Now that we have the necessary backdrop to better understand the several issues concerning the design of systems and infrastructures, their politics and mediations, we come to a point where we can actually start thinking about how to empirically address them. The permanence of certain 'industrial habits' in the way we design infrastructures, their services and interfaces, appear to be responsible for a set of tensions and discriminations that characterize our post-industrial society. Complex interrelated and controversial issues that are impossible to synthesize into single univocal problems appear to be hardly addressable through prevalent development practices and problem solving approaches typical of the industrial era.

As is illustrated in Section I, designers constantly evolved their practices and tools in order to meet emerging socio-technical needs. This includes research that often explored practices and methods to conceive and ethically curate the introduction of more sustainable and inclusive systems of products and services from the bottom up. Despite these methodological and theoretical improvements however, what today appears to be still missing is an ability of current design approaches to transcend existing top-down and bottom-up dichotomies and enable re-direction (Dilnot 2015; Fry 2009).

Instead of critically questioning the structures and agency of infrastructures that frame their possibilities of action, bottom-up practices and design activities still largely take place at the fringes. Alternative ways of making and doing are explored and formalized at the front-end of existing industrial systems and between their gaps, without acknowledging the necessary changes required on their behalf to properly support these innovations. To elude this paradigm and its dichotomies requires designers not only to explore how to set up new system configurations, but also to investigate what practices might be necessary to provide them with the proper foundations to safely develop.

The second section of this dissertation will illustrate how I started to approach industrial infrastructures as a field of inquiry and to explore what a possible 'transtructuring practice' to initiate and curate their transition toward more locally adaptive forms and functions may look like. In what follows, I will introduce a set of design explorations to show how to possibly open up industrial systems and infrastructure and make them receptive and supportive to bottom-up innovation. Design materials and forms have been here explicitly used to investigate what practices and processes might be necessary to reveal functionalities, agencies and logics behind present infrastructural configurations and collaboratively explore possibilities for their transformation.

The starting point for this inquiry is that to understand how to systematically change industrial infrastructures toward more citizens-centered configurations, a design facility with their scale, dispositions and back-ends operations, is necessary to guide this process (cf. Dewey 1954). This information however is often not directly accessible, naturalized in the background of human interactions (Bowker and Star 2000) and concealed behind their front-end interfaces and devices (Borgmann 1987) if not deliberately kept away from public scrutiny (Easterling 2014). Thus, certain actions might be required to render these systems present and available as material for design and participation, overcoming initial constraints and resistances.

The second section is divided in three chapters. In the first chapter I will provide an account of the methodological and theoretical insights employed to define a possible framework and approach to explore how agencies, networks and logics of present and future infrastructures can be made 'real' in the sense of becoming present for experience and design. This possible methodology and program has then been tested and rehearsed through a series of design experiments addressing last-mile delivery problems and broadband metadata market issues described in the central chapter of this section. Design fictions and critical interventions were here used as the means to engage publics with infrastructural issues and to materialize the figure of infrastructures and explore possibilities for their reconfiguration. The purpose of these studies was not to design and evaluate specific solutions but to explore what transtructural configurations can be, and what the design actions and materials of a redirective practice for their configuration might need to include.

The experiments provide clues to a very promising area for design when it comes to materialize infrastructures and critically investigate possibilities for their transformation. In particular they offer examples of the early prototype of transitional and redirective practice for the design and modeling of postindustrial infrastructures, attentive to diversity and plurality of interpretations and that are able to work across different networks and scales. The discussion and reflections about findings, meanings and political implications of this experimental inquiry will be reported in third and final chapter of this section. Qualities limits of this research will be here more deeply addressed, illustrating some of the possible contributions that this experimental work might bring to the development of design discipline and practice.

Research framework and methodology

Despite their familiarity, infrastructures might be an unusual subject for design. Indeed designers are used to work within them, providing solutions at the front end or improving functionalities and interactions at some points in their networks. However, for the purpose of their work, they do not usually need to be aware of whole system operations and disposition. Except when they are designing new systems and services from scratch, they are rarely asked to question the structures and functionalities of an organization. Nevertheless, to explore how to possibly transform industrial infrastructures towards more contextually adaptive configurations, we somehow need to find ways to relate to these networks beyond the access points we currently interact with. At the same time we need to learn how to work across multiple networks and communities of practice, shifting between different scales and locations.

Observations that open up a set of methodological questions regarding what type of knowledge, materials and design processes might be necessary to enable and curate change within these systems. In particular, the first problem we might need to address is the one of 'accessibility'. To open up infrastructures for re-interpretation and design we first need to find ways to make their back-end functionalities present and available for such interventions. But how do we deal with the fact that this information is usually privately held, deliberately concealed for competition and security reason and not open for these purposes?

Companies in control of infrastructures are generally interested in expanding their businesses and networks incrementally and in a commoditizing fashion. Everything that does not fit with their specific rationality and way of thinking is usually excluded. To maintain their business however companies needs to evolve. Something 'unknown' outside their system is usually evaluated, analyzed and framed according to their own consolidated knowledge and practices (cf. Heidegger 1977; Borgmann 1987). If functional to their purposes, new knowledge and bottom-up innovations can be eventually annexed and formalized within the existing system.

This approach allows for economic robustness, system efficiency and optimization. However, it also represents the main conservative force to the companies' ability to innovate themselves and a limit to their capacity address local and

systemic issues. Executive managements teams are well aware of these limitations. For instance the social, environmental and economic costs produced by last mile and digital divide problems are typical examples of the effects of this prevalent network-centered planning and design ways of working. Similarly the proliferation of standards and services in certain locations, which in most cases lead to delays and economic, material and energy resources being wasted, is a systemic result of these company-centered perspectives in systems development.

To learn how to possibly overcome these issues alternative ways of planning, design and prototyping infrastructures beyond prevalent single network or community perspectives need to be articulated. This could be experimented within the frame of a redirective practice aimed at questioning current infrastructural configurations and at the exploration of alternatives options and models of value creation, rather than delivering incremental solutions reinforcing the status quo. Nevertheless, this way of working is particularly unfamiliar to companies since it mines their consolidated practices and habits of mind.

This diversity of interpretation about what design is and what it does contributes to the problem of accessibility of infrastructures as material to design with. As long as the designer's work and intentions are aligned with the interests of their sponsors, some information about internal operations might be available. But if the purpose of design is to critically explore and question how to possibly change these systems toward more democratic configurations, opening up them for judgment, suddenly the possibilities to directly access information from the source are very limited. The design work starts to be perceived as 'destabilizing' —challenging established habits, work practices and power relations rather than consolidate them— with no clear economical return, and outside the logic of short term provision of functionalities companies are used to. These issues make access to information difficult to obtain and to argue for without materials or examples of possible outcomes, and are not just a matter of entrepreneurial ability to understand research and innovation.

The lack of transparency regarding the disposition and operations of networks and infrastructures also has political implications. Despite being (in many cases) privatized and therefore following market logic rather than the achievement of a 'public good', the operations and dispositions of infrastructures and services still represent a matter of public concern (Easterling 2014). Private infrastructures maintain a public function affecting, through their presence or absence, the

relations between global geographies and local economies, limiting or fostering citizens' life but not necessarily in preferable ways.

The possibility to access private networks for the purpose of public scrutiny should be, in theory, a prerogative of public life and democratic societies (Dewey 1954). Nevertheless, without a full intelligibility of these systems and all the possible consequences associated with their agency and performance this is not very likely to happen. Thus, certain interventions to produce the necessary material to design and engage publics in an exploration of their configurations and conceive alternative ones might be necessary and, at the same time, ethically justifiable. How to achieve this purpose though, breaking up the constant separation between inside and outside networks, local and global, top-down and bottom-up relationships without causing unnecessary damage and unpredicted rebound effects remains an open question.

Considering the critical nature of this intent and the sensitivity of infrastructures as a field of design inquiry requires designers to first explore and experiment with ways in which such practice could safely unfold. There are several legal and ethical implications concerning the security, privacy and reliability of these systems, the people they serve and employ, of which designers need to be aware of and for which they need to take responsibility of their actions. For this purpose this chapter will attempt to draft a possible framework for a constructive research approach to explore what a possible re-directional design program for the transition of industrial infrastructures might be (cf. Binder and Redström 2006; Redström 2011).

The scope of this framework is to first outline which activities might be necessary to include in this process. This will be later used as a base for a series of design exploration and evaluations of this approach and the possible materials it can make use of. The reason behind this need to experiment is simple yet important: essentially this is a kind of design current practices are not really equipped for. Different methods and approaches need to be first explored and prototyped before being able to clearly articulate what such a practice is, what it does and what it can deliver.

One way to inform how to build a new practice dealing with infrastructural transition and to identify where and how answers will be searched is by looking at theory. Considering its usefulness in articulating the relationships and dynamics through which socio-technical systems are configured and its perspectives— that

in many ways challenge and resists current industrial simplifications and dichotomies— Actor Network Theory will be here introduced as a possible conceptual scaffold to identify possible approaches to navigate the infrastructural space across its networks, people and practices they support. In particular, the concept of figuration will be here presented and expanded as a possible design tactic to understand and reveal the practices and logics of existing infrastructural networks and their designs.

A second extensive body of work to draw from in order to identify what this new practice might be is instead of the set of existing design and research practices that relate to infrastructures. As Cross (2001) argues "What designers especially know about is the "artificial world"—the human-made world of artifacts. What they especially know how to do is the proposing of additions to and changes to the artificial world. Their knowledge, skills, and values lie in the techniques of the artificial. (Not "the sciences of the artificial.") So design knowledge is of and about the artificial world and how to contribute to the creation and maintenance of that world " (Cross 2001, 54).

Since infrastructure represents an integral part of the artificial world, design practice might have already developed appropriate forms of knowledge, inherent to the activity of designing, regarding how to engage with their design. Thus, by looking at design 'as a discipline' we might identify practices and competences useful to relate to industrial infrastructures, their scale and multiplicity of actors. Drawing form these 'proto-practices' can provide us with a starting point to define what tactics and materials a redirective and transitional practice might need to include. These approaches might not be fully equipped for this purposes yet. However, it is by looking at their methods and tools that we might identify a possible way into the infrastructural space to explore possibilities for its reconfiguration.

Figuration

In his book "Reassembling the Social" (2005) Bruno Latour offers a series of concepts and strands of theory helpful to articulate a possible approach to different types of infrastructures in the digital, physical and social and their organizational architectures. Building upon the socio-technical construction, relational and co-evolutionary perspectives, Actor Network Theory suggests the impossibility of setting static universal definitions and analytical descriptions of

society distinct from its technical systems. As an alternative it offers an image of contingent continuously evolving networks and surfaces, whose form and meaning are strictly dependent on the situated agency and interactions between people and things that constitute them. As Latour argues, within a network there is no distinction between local and global, but they are part of the same thing (Latour 2005, 189). He explains this union according to how "the notion of network allows us to dissolve the micro-macro distinction that has plagued social theory from its inception. The whole metaphor of scales going from the individual, to the nation state, through family, extended kin, groups, institutions, etc., is replaced by a metaphor of connections. A network is never bigger than another one, it is simply longer or more intensely connected" (Latour, 1996, 5).

According to Latour (1996) the development of infrastructures can be described through the linkage of large heterogeneous arrays of technical elements and human actors configured across multiples spaces and times. A network implies no *a priori* relations. It is no tied to axiological relations between of top-down and bottom-up offering a way to navigate and trace back element across its hierarchies, its layers and scales:

> A network notion is ideally suited to follow the change of scales since it does not require the analyst to partition her world with any a priori scale. The scale, that is, the type, number and topography of connections is left to the actors themselves (. . .) Instead of having to choose between the local and the global view, the notion of network allows us to think of a global entity — a highly connected one — which remains nevertheless continuously local. Instead of opposing the individual level to the mass, or the agency to the structure, we simply follow how a given element becomes strategic through the number of connections it commands and how does it lose its importance when losing its connections. (5-6)

Due to their diversity, these networks of human and non-human agents cannot be generalized but need to be understood though the different local interactions, agencies and relations between their components. Similarly, despite their universality and standardized designs, 'technological' networks and infrastructures are always specific and contextualized. They support and affect with their agency different practices and communities, and acquire different meanings from place to place, constantly linking the local and the non-local in relational and reciprocal connection. Through this linking process, time differences and geographical distances are re-configured, producing new realities inside and outside these

networks; Processes that generate exclusions and discriminations in access to networks and infrastructures caused by the different economic power relations that dominate infrastructural implementation for which particular geographical areas and users are privileged compared to others (Graham and Marvin 2001, 8-22).

With technology and technical systems extending to every setting of human life the questioning of the mediations and influences of these networks become both an instrument for social analysis and necessary starting point for any propositional intervention. Because of their political and ethical implications, Latour argues (2005, 88), they are no more exclusive subjects of technical and scientific inquiry, but 'matter of concerns' which require us to unbundle and expose the complex set of relations and agencies among different actors, their motivations and interpretations, to be properly addressed. Once revealed, these socio-material constructions become questionable, making it possible to judge the qualities and appropriateness of their designs and configurations. In order to make this possible, Latour offers some methodological suggestion on how to trace these relations.

Relationships within networks and their human and non-human actors are continuously different and evolving (Latour 2005, 43-86). Neither a concept of society or the a priory definition of groups can be said to exist and be defined in advance before study. But knowledge about links, power relations and interactions between people and things must emerge from the field, leaving actors to define themselves and interpret the network and settings in which they are located. Actors act as mediators. They continuously transform the elements they are supposed to carry and therefore their specificity needs to be accounted all time. Every actor is made to act by many others and the agencies that play between them are always 'accountable' through descriptions and motivations, as a response and in opposition to the agency of other actors, and through some 'flesh and figures' that give them some form or shape. These materials and logics are what give form to a certain context and is what constitute a *figuration*.

'Figuration' endows agency with a shape (Latour 2005, 54). Not in a reductionist way, as it could be in a single representation or visual description of a network and the relations of its subparts, but it must (or attempt to) include as the many different interpretations, motivations and perspectives as the number different mediators and intermediaries that constitute a certain configuration. However, as long as these agencies and relationships remain invisible they leave no trace,

therefore they are not accountable. All infrastructures — both technical and interpersonal — inevitably tend to fall into the background of human interactions, naturalized in the everyday routines of social interactions, becoming invisible. Thus, Latour argues, if we want to have a meaningful argument about a situation or configuration, certain actions and performances are necessary to expose these agencies and connections between inanimate and human actors.

This means we need to find ways to make people and matters 'talk', altering the apparent stability of a certain configuration, habits and social constructions, in order to make exceptions, conflicts and unexpected trails emerge. To describe what such actions might be, Latour use the term Plug-ins as a way to name interventions that function to activate something that was not possible to see before, or "plug-ins lend actors the supplementary tools that are necessary to render a situation interpretable" (Latour 2005, 209). This metaphor borrowed from computing in many ways evokes activities and tools that already belong to the design practice. Methods such as 'cultural probes' for instance do actually share many qualities of plug-ins if we consider their ability to alter a certain situation and provoke reflection. Nevertheless, the motivation that guided their original development was actually explicitly dissociative from the social sciences. As defined by Boehner, Gaver and Boucher (2012), probes, "were developed as a declaration of independence from the implicit requirements of social science methods in an attempt to construct a design-centered approach to understanding people and settings" (195).

In her essay "Configuration" Lucy Suchman provides an expanded definition of figuration that might be interesting form a design methodological perspective. Besides exposing the relational ties within a socio technical system of reference, what Suchman seems to address is the importance of reanimating the "figure" of a system, the logic and purpose behind its design, as a necessary activity to articulate and produce the material semiotic required for its transformation and reconfiguration: "Figuration is an action that holds the material and the semiotic together in ways that become naturalized over time, and in turn, require unpacking to recover its constituent element. It is also, however, a mode of production, as the circulation of figures implies their re-contextualization, multiplicity and at least potential transformation" (Suchman 2012, 49). Thus, by revealing the subjective interpretations, agencies and practices of actors involved or excluded by the same infrastructure, 'figuration' provides a possible tool to approach the design and re-configuration of large socio-technical system.

Design knowledge and infrastructures

Redesigning infrastructures is a daunting task to say the least, and to realize a new one will involve a significant range of skills, professions and areas of expertise extending far beyond the reach of the design discipline. However, design might play an important role in the process of re-thinking them. Multidisciplinary, open and systemic approaches, that are attentive to diversity and plurality of interpretations are necessary when dealing with broad and complex socio-technical systems, and it is in this context that design discipline can find a possible leading position. Due to its knowledge about how to articulate issues through materials and make solution to complex problems experienceable, design seems the ideal candidate to provide the means to understand how to re-animate the figure and reconfigure industrial infrastructures opening them up to variety interpretations.

For instance, within participatory practices 'design games' have been historically developed as material to allow stakeholders with conflicting interpretations of a problem to share a common understanding of it and to collaboratively explore alternative solutions to matters of concern. As illustrated in the previous section of this thesis design practices are continuously evolving including a variety of methods aimed at dealing with the constantly increasing complexity of technology and society. Different approaches have been experimented with, including means to anticipate and explore the possible uses and mediations of technologies in their context and tools to engage publics in a discussion about matters of concerns. Drawing from this rich background can provide us with a starting point from which to build upon and to develop new approaches necessary to first render infrastructures accessible and available as material for design and participation.

Design's embodied ways of knowing

In the Reflective Practitioner (1995) Donald Schön describes design as an embodied and situated dialogue between the material and the situation. Through a continuous process of reflection-in-action enabled by sketches, mockups and qualitatively, knowledge emerges from the context allowing designers to qualitatively evaluate different styles and configurations, to restructure problems and redefine questions. Although this definition is still strictly related to professional architect and designers producing answer and solutions, Schön description still offer a good analogy of how practice based research works.

Like similar forms of art based research, the design process does not start from the formulation of well defined questions, topics or problems, but 'formulating a question' implies delimiting the space in which a possible answer can maybe be found through making and prototyping. Artifact and art interventions used during the design process are both tools to explore and to investigate a specific area as much as they are an outcome and a possible solution to it. According to the professor of Research in the Arts Henk Borgdorff (2011, 60-61), they embody the fundamental ideas and perspectives that "disclose the world for us and, at the same time, render that world into what it is or can be". Thus design offers us the means to investigate futures and alternatives by allowing new experiences, as "outlooks and insights that bear on our relationship to the world and to ourselves", affecting "the foundations of our perception, our understanding, our relationship to the world and to other people, as well as our perspective on what is or should be" (61).

Central to this process is the concept of embodied knowing and the recognition of how people construct their own understanding of the world through their bodies and sensorial experiences (Johnson 2011). This perspective is largely draw from Dewey's notion of 'experience' as fundamental source of knowledge (Dewey 1987) according to which there is an emotional, intellectual and practical unity that characterizes and renders them inseparable from the everyday life. By crafting 'experiences' a designers can make the different qualities and relations of a 'problematic situation' present and enactable, exposing the possible limitations that existing socio-technical habits and configurations might exert on the achievement of qualitatively preferable ones. Through this process of doing and undergoing, new knowledge is constantly produced, changing our understanding of an existing situation and producing the foundational new possible design interventions and configurations.

Although an appropriate philosophical distinction from the previous pragmatist views is necessary, Maurice Merlau-Ponty (1968) also addressed attention to the structures of experience and subjective consciousness about the interactions between people, places and things. In particular, Merlau-Ponty suggests how the relationship between humans and non-human actors cannot be fully described orally or as a priory, but always entails contextualized 'palpable' qualities. People, things, nature and the environment are mutually influenced by each other's presence, by "acting and being acted upon", sensing and being sensed at the same time.

Materializing networks

Design research and practice have developed a strong competence and a variety of tools to conceive and support the introduction of more sustainable and inclusive systems of product and services. This subchapter provides a description of a set of existing approaches dealing with the design and materialization of socio-technical systems and infrastructures we might need to relate to, considering some the environmental purposes and social implications that working with infrastructures implies. The aim of this exercise is to identify a set of tools to reveal and give a presence to existing networks of infrastructures and to identify possible methodological frameworks through which to possibly understand how to work with this material once made available. Different methods are here critically addressed and analyzed in order to expose some possible issues requiring more attention. In particular we'll here discuss what kind of information they provide; where they concentrate their actions, what they do actually reveal and render known. A methodological gap is finally identified, offering a possible ground and starting point to propose a new possible practice based approach to understanding how to enable user-led innovation for existing networks infrastructures and services, and to curate their transformation.

Co-design and participatory approaches

Participatory and co-design methods allow designers and researchers a deeper understanding of future users, fostering inclusiveness and diversity of interpretation in their process. Due to their capacity to provide more user centered solutions by better interpreting users' contextual needs, these practices are now also largely employed to guide the design and introduction of ICT applications and planning of infrastructures (Schaffers, Ratti and Komninos 2012). 'Design games', speculative designs and participatory sensing approaches are all methods largely employed today in a variety of ways to engage participants in a discussion about present issues and future possibilities in the early stages of the design process (Binder et al. 2011; Burke et al. 2006; Sanders and Stappers 2014).

The tools employed can be low tech, such as board or a role-playing game, or high tech, such as sensor probes or interactive devices, and they can be aimed at understanding present issues as well as to explore and speculate about future possibilities within workshops and fieldwork sessions. Despite these differences, these mockups and artifacts always have the same function: they offer the dialogical means to relate and enact socio-material configurations, allowing

designers to address questions, filter information and to explore a design space. For instance, 'design probes' are today a common tool to engage participants in expressing their needs and triggering their refections about their context and practices, as ways to inspire designers expanding their views (Boehner, Gaver and Boucher 2012) or as premises to participatory sessions (Mattelmäki 2005).

Participatory practices are now well established within the corporate and consulting environment as a means to ensure usability and provide users better product experiences (Hunt 2011). However, as cases like the Medea Living Labs in Malmö demonstrate, these approaches and methods are now once again taking a political stance, engaging communities with matters of public concerns, improving social awareness and experimenting in new ways of making and producing knowledge on a local level. This way of working challenges prevalent homogenizing and centralized top-down decision making process typical of corporates and policy making, taking into account the agency of their designs and the designer's responsibilities for her own actions.

Beside the undoubted richness of this approach and the admirable social and political commitment of many of these actives, we can still point out some practical limitations that demand attention. Independently from the extension of the project and commitment to the stakeholders, co-design practices concentrate much of their activities at the front end of infrastructures and within a design space already shaped and defined by established hierarchies, policies and infrastructures. Relations and interactions among users and companies are reframed to provide more inclusive solutions at the fringes of infrastructures, but it does not really affect fundamental power relations.

Social innovation activities from the bottom-up still produce solutions within the gaps left open by other governmental institutions and infrastructures. Within this frame participants and designers are rarely aware of the dispositions and operations of institutions and infrastructures that produced the context in which they operate. Thus this work might actually run the risk to be legitimated as a way to explore new kinds of 'markets', outside what is normally considered to be one. There is, in fact, a resilient tendency to categorize individuals within preconceived functional groups — 'teenager,' 'immigrants,' 'unemployed' 'makers' 'neighborhoods'— whose dynamics and issues can be possibly addressed and formalized through design. A categorization that might contrast with the necessity of stating individual differences as undeniable starting point for knowledge production and

strike with some of the feminist techno-science perspectives at the roots of these practices (cf. Haraway 1994).

System design for sustainability

System Design for Sustainability can be defined as a service innovation strategy aimed shifting the business focus from designing and selling physical products only, to selling a system of products and services (PSS) jointly capable of fulfilling specific client demands (Manzini, Collina and Evans 2004). The approach is the result of an increasing awareness about the limits of product innovation and eco-design strategies (e.g. life cycle analysis) in ensuring sustainability. Thus, the need to develop broader strategic methods aimed at changing society's consumption behaviors towards sustainable forms.

Firm analytical methods and strategic design tools have been developed to guide designers in the creation of sustainable production-consumption system and evaluate their improvement compared to current state (Vezzoli, Pruul and Coad 2010). These include, service interaction storyboarding, systems maps, web tools and guidelines to ensure the system's social and environmental sustainability and stakeholders' convergences of interest charts. The necessary knowledge to design these systems usually comes from the interaction with communities and stakeholders, thus participatory methods are also often included. Recent research on sustainable product service systems is now addressing the knowledge gap regarding the mechanism and factors driving the implementation and diffusion of this kind of innovations in the real world through transition management strategies (Ceschin 2013; Vezzoli, Ceschin and Kemp 2008).

This approach proved to be successful as it provided companies and designers with a set of tools to guide them in the non-trivial process of understanding how to configure and implement socially and environmentally sustainable system and solutions. At the same time, cases of companies converting to PSS approaches exist and several examples of bottom-up system innovation adopting its methods are available. However, beside the usefulness of this perspective in showing that alternatives to mass markets and consumption do exist, what seems to be a lack is an ability of this approach to address questions regarding the experience of these system innovations once implemented (Verbeek, 2006), along with its incapability to anticipate the possible systemic consequences of their agency and growth before they are actually implemented.

PSS illustrate how more sustainable and flexible production and consumption systems are indeed possible to conceive and to implement. However, questions remain unsolved regarding how to avoid bottom-up innovations framed and integrated within the existing capitalists logic of growth (Fry 2009, 151-155). In many cases, system innovations happen at the front-end of existing systems (cf. Morelli 2007) or at the 'niche' level. Small socially driven businesses and start-ups develop, fulfilling needs that existing services and infrastructure cannot meet, filling the gaps they leave open. Within the current paradigm, set up to serve scale and mass manufacturing, these small-scale initiatives struggle to manage and maintain their business models and supply chains. Their only option then becomes to find compromises, to scale-up or to be absorbed by bigger companies, limiting by de facto their reach and sustainability.

Participatory sensing and infrastructures' augmentation

With the diffusion of mobile phones and the growing affordability of embedded sensors and systems, participatory sensing emerged as a way to form interactive, participatory networks that enable public and professional users to gather, visualize, analyze share local knowledge (Burke et al. 2006). Due to their affordability and ability to reveal hidden aspects of everyday life, sensor probes have been often employed in participatory design as a tool and a method to engage citizens in the collection of data about their cities and to create their own rationale about matters of concern, such as air quality and traffic density (DiSalvo et al. 2008; Kuznetsov and Paulos 2010a). In addition, several examples of grass root initiatives, or socially driven services and collaborative sensing networks where citizens produce and share information and resources about and within their cities and communities are available (Townsend et al. 2011).

Recent experiments and projects have been also dealing with citizens' exploration of large-scale industrial infrastructures and their relation with informal bottom-up communities through methods of infrastructural augmentation. Augmentation consists of adding information processing and ability to generate data to objects and systems unable to produce them, providing enhanced possibilities for experiences and interaction with their users (Kuniavsky 2010). In the MIT Senseable City Lab 'Trash Track' project citizens have been invited to help exploring how the waste collection and recycling system of their city was operating. Different types of trash have been 'augmented' and equipped through small location aware devices enabling the system to produce information it

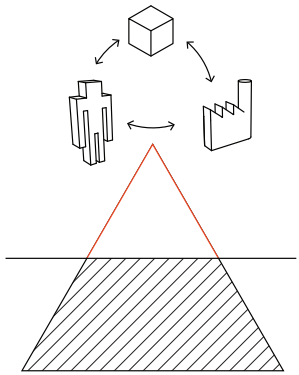
could not otherwise provide. As a result a map of unknown aspect of a large urban networks like waste removal was produced and made available to citizens, companies and academics for judgment, analysis and research (Offenhuber et al. 2012). In a similar way, in the project 'Forage Tracking' instead, GPS devices have been used within a participatory design process to reveal the functioning of informal recycling cooperatives and to facilitate their interoperability with public and private institutions (Offenhuber and Lee 2012).

These projects open up new opportunities and offer a glimpse of what methods and tools could be used to explore for allowing access to infrastructures. At the same time they offer new possibilities to study and engage with large existing physical infrastructures and identify opportunities to relate and makes sense of large-scale systems dynamics otherwise impossible to grasp. This is because technology does have the ability to describe and present world and its phenomena differently. At the same time though, we should be aware of the political implications of these projects and what is that is actually revealed and how.

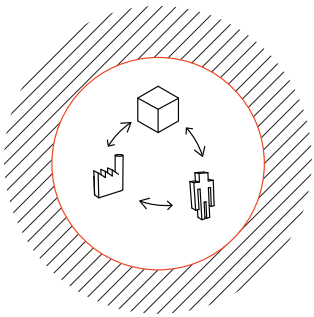
Beside possible observations on the politics of representations and data used in these projects (cf. Suchman 1995), what is interesting to notice here when looking at the examples provided is that functionalities and operations of the large 'formal' infrastructures always remain hidden. Participatory sensing is used as a mean to reveal and incrementally render accountable something unknown at the front-end of existing infrastructures, in a top-down manner, to produce information with a level of detail and granularity their measurement instruments can not typically produce; to reveal, formalizing it, something unknown from the bottom-up; or to reveal an informal social organization in order to generate new synergies between it and existing formal infrastructures. Nevertheless, protocols, materials and logics of the systems that actually determined a certain situation and design space still remain concealed and unquestioned.

Counteracting invisibilities

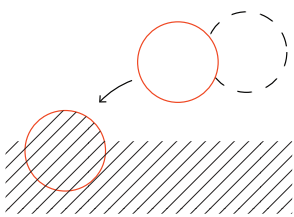
From the different approaches described and case studies mentioned, what is apparent is that these methods and approaches are generally located at the front end of infrastructures, aiming for a basic understanding of the existing configurations as a starting point for design. Thus, such processes run the risk of not being able to address the underlying functioning and logics of the infrastructures shaping the design space. Standards and protocols driving formal institutions



1. User centred and co-design approaches limit their action at reconfiguring interactions on the top of existing industrial networks and infrastructures.



2. Niche and bottom-up initiatives make something transparent by showing radically different ways of doing and solving problems, creating new infrastructures.



3. Bottom up and social innovations render something new and 'informal' transparent and available. This can then be incorporated within existing industrial structures, their protocols and practices.

are never accessible to participants and designers for judgment and are always taken for granted. Rather, most of the time are yet uncontrolled and unknown phenomena at the fringes of infrastructures that are revealed and rendered transparent.

This way of designing and working with system and information it can be argued, still pretty much conform with the industrial way of design and look at the world as described by Heidegger (1977) and Borgmann (1987), since it produces, intentionally or unintentionally, commodities. Bottom-up innovation, informal organizations, sensing networks and start-ups all render transparent and available something, such as new information or a new way of doing or fulfilling a need, which might have some value for some other actor, company or institution. Once made accountable, niches and bottom-up innovation become formalizable and possible to integrate within the existing paradigm, its infrastructures, protocols and logic of growth. This 'enframing' process often ends up changing the social and sustainable qualities of bottom-up innovation. If we want to maintain these qualities instead, by shifting the way society and infrastructures functions systematically, we need to reverse this process directing by spotlight towards infrastructures rather than outside them.

The inability of current methods to actually provide the means to relate and inquire existing networks and organizations that frame the design space represents 'a gap' between them and this present research questions. Only by addressing the required changes within these networks can we understand how to purposefully apply technology and support the diffusion of more sustainable and people-centered ways of making and doing without replicating previous mistakes or come to compromises. Thus, the designers' attention needs to shift from the design of new systems of products and services on the top of existing networks to infrastructures and their foundations.

We can therefore start outlining what a possible redirective and transitional practice might look like and what tools it could include. The basic premise behind this work is fairly simple: since the first obstacle is one of accessibility, this is where we need to start — to materialize that which is otherwise hidden in order to make it available as material for design. To reanimate the figure of infrastructures, tracing their present working and agencies, it's a necessary first step to counteract their naturalization and activate the agencies of their different mediators and actors. Then, after materialization, we can start exploring what practices

are needed to enable change within current configurations and to create new forms out of this material, opening up for participation and allowing citizens to construct their own rationale regarding these 'infrastructural matters of public concern' (cf. Haque 2010).

Indeed there is a solid ground of design methods and approaches from which to build upon for this scope. For instance, augmentation and participatory sensing provide the means to render visible networks otherwise impossible to relate to, while system design and scenario approaches offer the necessary tools and knowledge to conceive more sustainable solutions and services. Finally, speculative designs and participatory 'infrastructuring' practices allow for the expression and investigation of possible future configurations and their mediations in their context of use.

A programmatic framework

As a way to guide actions and systematically inquire into the field of infrastructures, I will here draft a possible programmatic framework for a redirective design practice aimed at engaging publics with infrastructural issues through the materialization of present and alternative future configurations. The basic idea behind the definition of a program is to frame a possible design space within which to experiment and explore an original hypothesis (Binder and Redström 2006; Redström 2011). In this case, that the diffusion of more sustainable and distributed models of production and services supply requires a new type of infrastructure, a 'transtructure', to properly support their supply chains and operations. Nevertheless, this design is not achievable through established 'industrial' processes. Hence, there is a need to explore what kind of practices might be necessary for this purpose.

The purpose of this initial program is therefore to research and evaluate a set of design experiments and interventions of what a transtructuring practice to possibly configure and set into being transtructures might look like. This means not only to investigate ways to properly attune this new type of socio-technical arrangement to always different contextual needs, but also to acknowledge what changes it will require on behalf of the industrial systems across which it will operate to properly support its development. Considering the groundwork nature of this inquiry, design experiments will be therefore used more as way to know what is important about the original hypothesis and research questions

rather than reject or affirm them. The wish is that this very initial program could possibly open up an interesting design space where further and future developments are possible, providing a glimpse of what a transitional and redirective practice for the design of transtructures can be, and the type of forms it could produce.

This first experimental program is built on two main themes:

- Making the *infra*-structural available as material for design.
- Prototyping and staging of futures concepts.

In what follows I will provide a description of the revealing, tracing and staging activities that constitute it and its general structure. This process is not linear and every one of the activities it includes should be adjusted to the contextual contingencies, qualities and kind of infrastructures addressed. By making it explicit it is a way to invite others designers and researcher to adopt it and rehearse it, exploring its potentials and limits in different contexts and within different kinds of infrastructures in order to expand and validate it (Seago and Dunne 1999).

1. **Revealing:** To trace and materialize the present working of infrastructures can be fundamental to allow citizens to construct their own rationale regarding matters of public concern (DiSalvo 2009). However, to open up infrastructures for re-interpretation and design, we first need to make them relatable understandable reanimating their figure. This means exposing the logic, materials and purpose behind their design, but also their dispositions and the different practices they include and support in different places and locations. Thus, the first thing designers need to figure out is how to properly visualize and materialize this work and make the back-end functioning of an infrastructure available for discussion and judgment. These can be done in multiple ways according to the specific contextual design needs and level of access to information e.g. is there support of a company or not. When direct access is not available, 'hacking', intended as provocative act moved by curiosity and the desire to amplify the interaction with the world and without destructive intent, is an approach that may well fit this purpose (Von Busch 2009). Mobile, DIY electronics and off-shelf devices can be used to augment and visualize infrastructures, such as in participatory sensing practices related to infrastructures (Shilton et al. 2008; Offenhuber and Lee 2012). Other forms of exploration instead could include different activist practices

and repertoires aimed at exposing the figure and disposition of infrastructures and that can be adopted according to the circumstances. For instance 'infiltration' could be used as a possible tactic to explore sites and retrieve information and material through active presence[16]. Many other different techniques can be used for the same purpose. In her book Extastatecraft for example, Keller Easterling (2014, 211-238) offers an account of several possible non-conflict techniques, including the creations of fictions, gossips or forms of exaggerated compliance as ways to expose the disposition and active forms of these system.

2. Tracing and Probing: Once visualized and materialized, the images of the infrastructure that have emerged can be turned into material for design and used as a dialogical means to capture the different subjective interpretations and practices of actors involved or excluded by a same infrastructure. By exposing the different representations and imaginaries of the same system, new alternative configurations become visible, opening up opportunities to re-enact relations and feedback loops differently. These accounts can be the included in an iterative design process leading to the identification of appropriate shared representations and alternative preferable solutions. Appropriate tools and design can be crafted for this scope according to the context, allowing designers and participants to understand existing configurations of the infrastructure inquired and its multiple interpretations. Design tools such as 'probes', can be used and given to communities to reveal and expose the underlying functioning of infrastructures. For example, design kits can be crafted as a means to engage people in the exploration of the functioning, logics and disposition of infrastructures, tracing back "the origin of an issue"(DiSalvo 2009). This tactic can be employed to learn about the infrastructure and reflect about what they do, the issues they generate and what they could possibly do. Cultural probes can be also delivered to participants and members of a community as a way to expose their practices and interpretation of their contexts (Boehner, Gaver and Boucher 2012; Mattelmäki 2005). These crafts will be needed to engage users in sharing ideas and desiderata with the designers and other participants and to expand views and express the diversity of understanding regarding a specific matter of concern; materials that will then provide the premises for the re-configuration of networks and infrastructures.

16 The practice and theory of exploring usually inaccessible urban spaces: http://www.infiltration.org/

3. **Staging in the Field:** Once the existing configurations and interpretations are made present, new concepts can be collaboratively conceived out of this material. Prototypes, mockups and design fictions can be crafted and used to enhance people's creativity and materialize different scenarios and interaction between local and global systems. These can be then used to stage and rehearse these concepts in the field through open and iterative participatory processes of experimentation aimed at engaging publics in a discussion about future possibilities (cf. Halse et al. 2010). By offering an experience of a future configuration as close as possible to real life, knowledge about the possible mediations of these future configurations can be explored. On the one hand by encountering the design work, citizens can relate to this futures —breaking with their habits— compare it to their present condition and externalize their diversity of perspectives and worldviews. On the other hand, by opening up their process and work for interpretation, allowing people to openly questioning and interrogating it, designers are thereby given the tools to better interpret the possible consequences and mediation of their designs (cf. Brecht 1964; Tracy 1994). Through this dialogues, new issues, ideas, possibilities and practices can emerge. This can be then further explored by the designer and addressed through different aesthetics and prototypes, allowing designers to probe into a context and its communities, understanding how to curate or re-purpose their plans and designs according to them (cf. Redström 2008; Tonkinwise 2011).

Prototyping a practice

This chapter will present a set of design explorations of strategies in tracing and materializing existing and future infrastructures so that they can become available as material for design and participation. These experiments constitute the empirical body of work of this thesis and have been conducted primarily within two types of infrastructure with radically different qualities and features. Firstly, the material flows of logistic and delivery services and secondly the information and data flows of broadband networks. The aim of these experiments is to start looking into what a design practice addressing the transition of these networks towards more sustainable and adaptive postindustrial forms might be like; to investigate what kind of knowledge they produce and evaluate their possible role in a design process aimed at democratization of large industrial infrastructures. Thus, the purpose of these experiments here is not to prove concepts or evaluate the quality of end-results, but to prototype[17] new design uses and practices able to address contemporary socio-technical needs and possibly overcome present design issues.

The first set of experiments focused on logistics and delivery systems, and how their close ties to industrial urbanization could be opened up to better respond to the needs of sparsely populated rural areas and issues of 'last mile distribution'. 'trojanboxes' (1) and 'drone-postbox' (3) represents the main body of this work, providing together an example of how the whole initiative process of transformation of industrial systems and the design of new transtructures can look like. From design interventions made to expose the properties of logistic networks in an area that is currently poorly served by such services a new speculative design concept of a distributed delivery network in the countryside performed by drones have been conceived. Mockups of this concept have been then produced and used to stage and rehearse the service in field with the local inhabitants. Along the course of this process, sets of 'mid-explorations' (2) have been also carried out, including site explorations and practicing with designed forms of public engagement. These activities took place non-sequentially and for multiple purposes, such as the continuous attempt to establish a relation with delivery service suppliers, confirm data and observation from other studies and

17 The idea of 'prototyping practice' is largely derived from an ongoing research program at Umeå Institute of Design that partly contributed to funding this research: http://www.dh.umu.se/en/research/research/programmes/

gain experience with fieldwork performances. Finally 'Antenna' (4) is a fictional device made for hacking into mobile networks. It was prototyped as a way to articulate issues and possibilities for design interventions and initiate bottom-up innovation within otherwise inaccessible infrastructures.

All together these experiments offer a portfolio of possible redirective activities through which to critically inquire into the present and future infrastructures and to identify alternative possibilities for their qualitative transformation. As a way to support the argument, an emphasis on the visual and physical properties of the designs and material produced, I here make extensive use of images, as a way to enrich the reflections and descriptions of the case studies by making the material 'to speak' largely for itself as in a type of annotated portfolio (cf. Bowers 2012). After presenting each project, I will then provide an analysis of their results, qualities and limits. These will provide the necessary foundations for a final evaluation of these projects in relation to the original program and its purposes, and a discussion about their possible contributions to design research and practice.

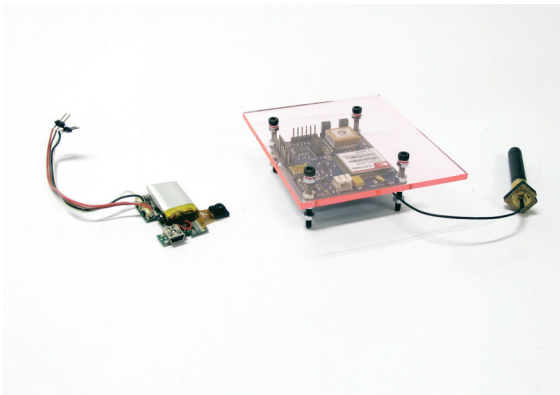
1. Crafting trojanboxes

Trojanboxes is the name given to a set of camera and GPS-equipped sensors probes crafted in order to be employed in participatory approaches as a tool to allow people to relate and engage in the exploration of a logistic network. Because of their ability to secretly provide access and to reveal networks' structures, their name is explicitly referring to the Trojan horse used by Ulysses to access the city of Troy and the non-detectable computers malware that share the same name. Despite these analogies, the probes do not share the same disruptive intent and consequences.

Although hackers sometimes operate close to what is illegal or even past that border breaking into forbidden or private networks, 'hacking' can be also defined as a practice aimed at opening a systems, accessing them and learning how to master their functioning and structures (Von Busch 2009). The trojanboxes clearly aim for the latter. They are tools to support new knowledge and creativity rather than to cause damage or change within systems; a positive, provocative act made in order to build new things, moved by curiosity and a desire to amplify the interaction with the world, without destructive intent (Mitchell 2005).

Before reaching their final form, different functionalities and configurations of the trojanboxes have been tested and evaluated. This prototyping process will be illustrated here, providing the necessary backdrop for a set of reflections and evaluations of this process from the designer's perspective. In particular, I will here discuss some of the properties of the materials these probes produced and their ability to provide engaging ways to expose hidden aspects of infrastructures (Davoli, Redström and van der Vleuten 2014).

The first challenge of this project was to identify the necessary means and materials necessary to relate to large logistic companies, their functioning and interactions in space. Although some kind of interaction did take place, without any contract or formal collaboration agreement it was very hard —or better impossible— to obtain companies attention and permission to access their back-end information and operations; even less so to experiment with their networks and assets. Even when the possibility to visit and explore their facilities was granted, the level of accessibility as an external researcher was still very limited. This is because of security and privacy reasons but also a legitimate need from the companies to avoid any possible interference in their performance and ensure their reliability to all their stakeholders and customers. As a consequence of this initial resistance and constraints, was the necessity to develop alternative ways



A trojanbox, its camera and GPS unit.

to produce knowledge about these systems and the necessary material for my investigations.

I therefore started to looked at different possibilities and methods to provide an experience of the back-end functioning of a delivery services, identifying what kind of material they can produce and evaluate their use as possible design probes in a participatory design process. The local postal service of the city of Umeå, in Northern Sweden, became the test bed for a series of small hacking experiments using consumer and do-it-yourself electronics aimed at exploring possible tools to trace the underlying functionalities of logistic services. Once tested and evaluated these different components and have combined into the trojanboxes' final configuration. The aim of this work was to explore the first stage of the preliminary research framework, namely that of creating the material necessary for any kind of design process to begin.

Delivery systems

Being one of the several freight distribution actors in the city, and probably one of the most accessible, the postal service was selected to be target of this study. In recent years concerns about the social, environmental and economical impacts of urban freight distribution have grown to expose the slow responsiveness to changes in current planning methods (Lindholm and Behrends 2012). Despite the higher level of efficiency offered by single actors and services, their heterogeneity, conflicting and lack of data make shared holistic solutions to city logistics hard to find and organize (Dablanc 2007). The postal infrastructure is part of the global logistic network and shares several features with other logistic services. This makes it a good case study to understand how to open systems explicitly set up for top-down control and in service for global economies, repurposing them to serve the specific needs of cities and local communities.

With its internal innovation protocols and standardized supply services, the postal service represents a typical example of an industrial infrastructure. As such, it shares many of the evolution patterns and problems related to naturalization, liberalization, commoditization that has been extensively discussed in literature (Borgmann 1987; Bowker and Star 2000; Graham and Marvin 2001). The derived demand, time and location criteria at the base of its organization are also at the root of many consequences of logistic networks both on the rural and on the urban landscape. For instance last mile delivery problems in lower

density areas in the countryside, the consumption and traffic congestions in large metropolitan areas and the splintering of communities in the disembodiment of the urban landscape (Dablanc 2007; Graham and Marvin 2001; Hesse and Rodrigue 2004; Lyster 2012).

Postal systems, like many other global logistic networks, are organized in more or less the same way everywhere regardless of the city geography, regulations and social context (Dablanc 2007; Hesse 2002). Originally designed to serve and meet the primary needs of supplying diverse communities at long distances, today's postal services have incrementally developed more decentralized networks to provide more extensive pick-up and distribution points to their customers. As part of this proximity strategy, tracking services showing the different transitions at different delivery stages have been introduced, e.g. showing when a package moves from a truck to a warehouse. Despite these transaction points given by online services and front-end interactions, the entire back-end of the delivery process and its performance are inaccessible from the external user's perspective.

Experiments

New mobile technologies and embedded systems can offer cities and companies new possibilities for involvement and participation in the study and design of their services through open innovation, bottom up and participatory approaches (Schaffers, Ratti and Komninos 2012; Von Hippel 2009). 'Hacking' is not only a way to illegally obtain information but also a source of innovation for companies. A famous example is Lego and their Mindstorm. Once it was hacked, the company recognized the value of opening up their innovation process as a general strategy to explore new market possibilities (Chesbrough 2010). Following this example, Ford is now inviting people to 'hack' its cars to develop new possible mobility applications ("OpenXC," n.d.). Similarly, participatory sensing and augmentations have been used a tool for analysis of infrastructures and the design of collaborative services for cities (Offenhuber and Lee 2012; Shilton et al. 2008; Townsend et al. 2011).

In the context of such developments, I carried out two experiments where, instead of investigating informal configurations of a design space, probes were here used to hack and materialize the functioning of formal infrastructures. The initial question that triggered them was extremely simple: how to open up an existing system and understand what happens to parcels from the moment they

are shipped to the moment they are delivered? Not having access to the postal service's sorting procedures, datasets about vehicles' locations or final destinations of mails shipped, I combined two methods to access and expose their back-end functioning: augmentation and the do-it-yourself practice of hacking. This approach has been necessary to be able to follow and retrieve data about paths and locations of envelopes and parcels from their origins to destinations; information the system is not providing to end-users. This approach was then applied to the postal service in series of experiments that provides information at different scales.

The very first attempt in this direction employed an off-shelf GPS tracker placed inside envelopes and parcels to follow, in real time, the delivery paths in the city to identify facilities, locations and timetables of the infrastructure network. Through the experiment the spatial organization of the system and its decentralized network was unveiled, offering a narrative of the mail distribution journey and the standardized time/location criteria behind its design. Not completely satisfied by the inability of the parcels to capture, for instance, indoor activities, I started experimenting with additional features and devices. In a second iteration, "Parcel View", a tilt-triggered camera was placed in to packages, providing a more detailed account of how work gets done at different stages along the delivery process. Finally, I decided to create a do-it-your-self real time tracker in order to have more control over the GPS files and to speed up the mapping process with the intention to provide users and designer with a possible interface to visualize and comment in real time on the parcels journey.

The goal of the experiments was not to provide an accurate or scientific analysis of the mail systems and distribution networks, neither was it to present a new organizational model for this specific service, but to evaluate if this approach and tools could be used within a design process. For this purpose it was not in the project's interest to reveal any sensitive information meant to be secret and secured. Rather it was explore how these kinds of hacks could be used to make sense of something that is already partially visible and available, obtaining new perspectives on the existing networks and uncovering new design opportunities. As a way to asses this capability, at the end of these experiments all the devices, videos and visualizations produced were gathered and evaluated according to the following criteria: their ability to produce interesting content; the level of engagement they could provide; and their possible use as tools to support learning and creativity.

Four mails

A first attempt at this intervention was made using regular GPS logger with an extra external power supply. However, this solution did not provide the desired results due to the inability of this device to maintain a continuous connection with satellites. A second test was done using a relatively cheap and off-shelf device, a Garmin tracker GTU 10, attached to four envelopes. This device is a high-sensitivity GPS (Global Positioning System) assisted by cell tower triangulation for approximate location (A-GPS). This is an important feature since envelopes spend most of the time indoors. Finally the device had a battery life of approximately three days at a position-logging rate of 5 minutes, enough to cover the entire delivery and a real time tracking service via mobile and desktop computer.

The second experiment took place in the winter 2012. One by one, the envelopes were shipped to four different addresses in neighborhoods located at four cardinal points in the city. This was done to cover as much as possible the city area and to make them arrive in different distribution nodes. Mail 1 and 4 have been shipped from mail drop boxes within the city center using ordinary mail, while mail 2 and 3 from our university building via ordinary mail. The GPS logged its location every 5 minutes, offering an accurate detail of the paths taken by the envelopes and the distances they travelled. The mails have been shipped one after another and they all arrived at destination with no particular problem. All the deliveries took between eighteen to twenty-four hours to reach their final destinations.

The data from the logger was retrieved through the Garmin web service. Unfortunately this service does not allow direct access to the GPS paths files. Once the envelopes arrived at their destinations, their waypoints and time stamps had to be transferred manually from the web service into an Excel file and then further into Google Earth in order to visualize their path. To verify the accuracy of the data and paths taken during the deliveries, all waypoints, distances and timing have been recalculated using Google maps. This procedure allowed overcoming the discontinuity in signal transmission that affected the GPS devices. Even if some of the waypoints were missing this procedure confirmed that the information obtained from the tags was reliable and that the waypoints time stamps was coinciding with the estimated travel time of Google. Finally, the shortest paths between start and destination point was calculated and compared them with the actual travelled distances and delivery time.

The GPS study allowed me to follow the envelopes in real time and to map the system's decentralized network and its performance. The spatial organization of the postal infrastructure follows specific functions. Locations of main nodes and sorting facilities in the city have been identified, offering an idea of how the network is organized, how it operates and how much space it consumes. Large collection and sorting centers are connected to industrial areas and main transport infrastructures, like airports and highways, while smaller pick-up and distribution points are located in the main neighborhoods.

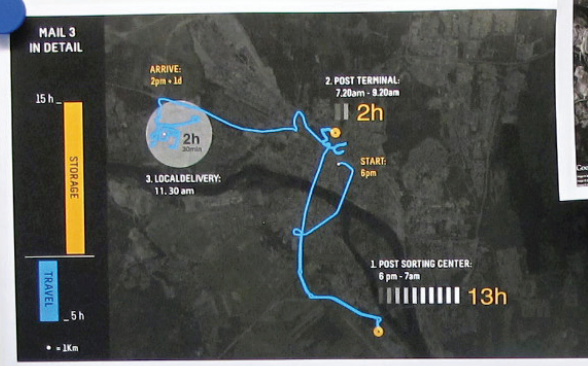
In the afternoon mails are collected and transported from the drop points to the main sorting center. Mail 2 and 3 were collected at 6:00 pm and reached the main sorting center 30 minutes later. Mail 1 and 4 were collected earlier in the morning at the university and travelled all around the campus, presumably to collect all the other mails from university, before reaching the same destination with an ad hoc service. Mail 1 reached the main sorting center at 3:25pm and mail 4 at 4:48 pm. Once sorted, they remain here for 12-13 hours and then transported to secondary nodes and post terminals where they are collected and distributed by postmen. All the deliveries took between eighteen and twenty-four hours. Data about of how many kilometers were travelled for each delivery and an indication of what roads delivery vehicles use most frequently has also been provided. Unfortunately, accurate measures of the parcels' speed was missing, nevertheless the study still offered several insights and material for reflection about the distribution process.

The delivery time of the different envelopes vary independently from both the effective distance between start and arrival points and in relation to the postman delivery decision about the paths to take. For all the envelopes, the time spent in storage is on average much longer than the time spent traveling. Similarly, the distances travelled by each of them are usually much longer than the actual distances from the drop location and final destination. In particular, most of the time is spent in the main sorting center, which operates according to all the incoming and outgoing national and international parcels arriving by airplanes and long distance trucks.

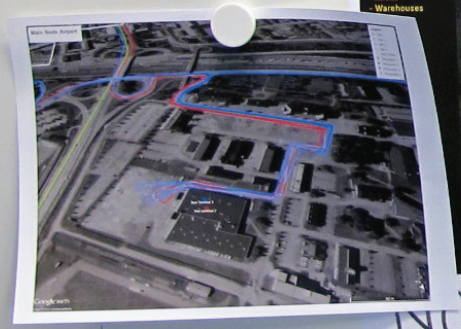
Four mails: one of the parcels equipped with the Garmin tracker employed during the experiment.

Next page: maps of the four deliveries and satellite images of logistic nodes and sorting terminals.

DECENTRALIZED NETWORK
VS
DISTRIBUTED

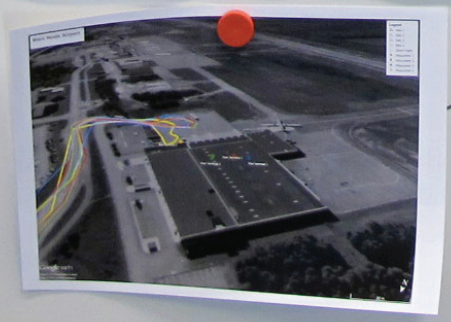


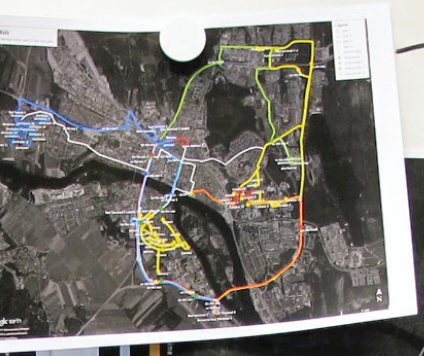
MAIL 3



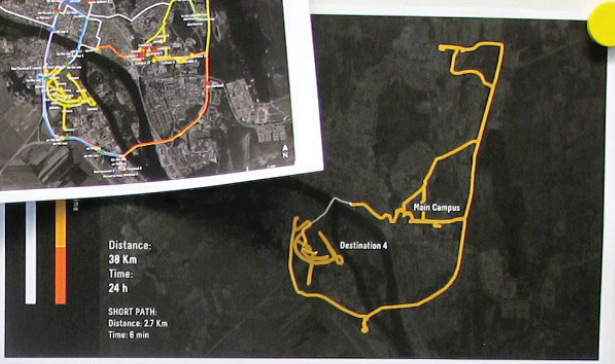
HIGHWAY
NODE

NODES





REAL TIME LOGS: INTERCEPT?



MAIL 4

MAIL 2

AIN
ORTING
CENTRE
(AIRPORT)

REAL TIME STORAGE AVAILABILITY?

Parcel view

This second intervention involved installing a small outward facing pinhole tilt triggered camera inside a parcel as a way to provide an account of the delivery process from a parcel perspective. With the help of the Dutch interaction designer Ruben van der Vleuten who provided the necessary code and inspired by his previous work "from A to B" — where a camera in a cardboard box was used to record the operation of a post delivery service of a large European city — I started experimenting possibilities behind using a modified camera controlled through an Arduino chip, an open-source micro controller. The camera was programmed to take a three-seconds video snapshot including audio every minute. Additionally, tilt switches acting as movement sensors had been connected to the camera, ensuring the camera would record 30-second videos any time movement was perceived (under the assumption that the moments of movement were the most important and interesting of the mailing process).

Light sensors were used to prevent the system from draining battery power and saving memory when it was not bright enough to record anything. A few tests of the DIY camera have been conducted, producing some footage of the journey but always proving to be unable to record the full door-to-door path. The fine-tuning of the camera was very time consuming and not really reliable. Thus, after finding a suitable and relatively cheap off-the-shelf device with the same features for this purpose — a Zetta Z12 camcorder, one of those usually installed for car insurance purposes in countries such as Russia – It was decided to switch to this ready-made option. After a first test the camera appeared to be reliable. The camera was shipped in a box supported by a 5000 mAh battery pack and programmed to record a 30 second video every time the device was perceiving movement. The recording was successful and able to record the entire delivery trip.

Through this video, the different stages along the delivery process, from collection and sorting to distribution, have been revealed, offering an account of how work gets done. Organization and man-machine interaction becomes accessible, providing a way to makes sense of a reality ignored by most. I've identified thirteen stages: reception at post office; storage at the post office; transport at the main sorting center; reception at the main sorting center; sorting; collection; loading on trucks; distribution; arrival at local node; transport mode change; final delivery. Only four out of these thirteen activities are perceivable by external users and only in two of them did users had an active role: at the beginning and

The delivery process and experience of the infrastructure from a parcel perspective.

the end. For each of these steps I analyzed which activities are carried out by humans, which ones are fully automated and which ones need both.

From the video one could identify how and where people are employed along the process. Compared to previous footage, such as the one provided by van der Vleuten's previous experiment's "From A to B", human activities here seem to be still necessary along the entire process, while in "From A to B" the sorting process appeared to be more automated (Davoli, Redström and van der Vleuten 2014). Employees activities are identifiable at the front hand in the post office; in the warehouse unloading incoming mail containers with the assistance of specific devices such as conveyer belts; sorting incoming mail, scanning verifying the readability of addresses and zip-codes, and during trucks load and distribution.

Here again interiors and their organization within the sorting center follows specific tasks. From the footage I could identify five different environments: post office and its storage space; storage space at the main sorting center; sorting area; collection and loading area. Each space is designed and planned to accommodate specific functions within the process, the use of certain machines and optimize the interaction with other units, such as the loading and unloading of vehicles. Finally, I could reflect on what information can be usable for external users or small businesses. In this case the attention fell on the storage areas in the main warehouse, and the delivery trucks — spaces appearing to have potentially latent space available and that could be used for other purposes. This notion could not be further investigated within the frame of this experiment and its materials, but that was addressed through other types of investigations described in this dissertation.

Qualities of GPS infrastructures

Similarly to what happen in the evaluation of the camera performance when comparing the DIY device with the off-shelf one consideration had to be made also in regard to the GPS unit. The Garmin device used within the first experiment proved to be quite reliable in terms of accuracy and battery life, as well as with an ability to provide approximate location also when within buildings. However, one of its main flaws was that it is a closed service with no direct access to the GPS files. A premium account is needed to visualize the last Garmin real time tracking service, and to manually export data to for instance Google Earth can be a very time consuming procedure.

Qualities of GPS infrastructures: the Garmin and the Google interfaces on the top and, below, the alternative DIY. The first is very reliable and able to work within buildings, but it doesn't have much flexibility of use. Thus the necessity to juggle around it and work manually on the data points it produced. The DIY unit was indeed better in answering the project's needs, but at the same time it was very weak and its development very time and resource demanding.

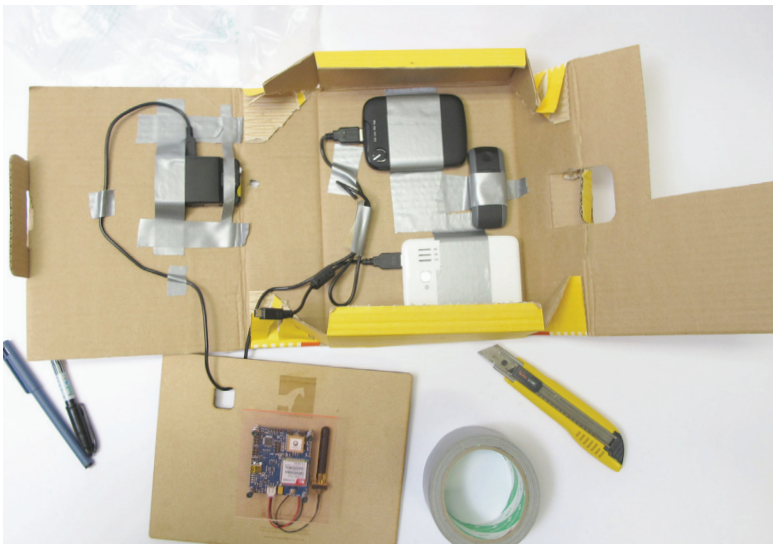
To simplify the process, I decided to create a real time tracking system of our own with the help of a supporting engineer using a "GeogramOne" board, an open source GPS device using a standard mobile phone SIM card. The new device was connected through a SMS gateway to our server, providing real-time location data through the GSM network. The information was then displayed on a website making it possible to share and follow the package simultaneously with other participants. Unfortunately, this design turned out to be relatively ineffective as the sensitivity of the GPS tracker of the open source device was much inferior compared to the first solution. The satellite fixation was often lost and never recovered during the experiments making it impossible to entirely track the parcel's pathways. I finally decided to keep both devices and use them in parallel. The solution did not resolve the basic problem of having to do the final mapping of data into maps manually, point by point. Nevertheless in many cases, the data from the two devices were integrating each other, offering more waypoints for each journey. Additionally, the open source trackers apparently gave the packages a more 'techy' appearance that somehow resulted in a more engaging for participants involved in the second stage of these experiments (3).

Reflections on the hacking experiments

The results obtained from these hacks indicated a series of promising features, offering the material for some comments and methodological considerations about their possible employment as participatory design tools. First, video and geolocation data provided two different engaging ways to reveal and understand the functioning of large, otherwise ungraspable urban logistic networks, helping me to articulate problems and opportunities. Secondly, they provided the material to think about alternative uses and interactions with the infrastructure, identifying possible points in its network to jack in and build upon. Finally thinking with software and electronics exposed, by expressing the differences between DIY and industrial devices and platforms, some of the relations and qualitative differences between top-down and bottom-up systems addressed in the background section of this thesis.

Engaging explorations

The first observation, and probably the most important, is that the probes allowed the playful exploration and tinkering with the infrastructure, understanding the system and its features: what it does, what it does for others and what it could possibly do. These characteristics are extremely relevant for participation



The trojanboxes final configuration: off-shelf camera on the left, two battery packs with the off-shelf tracker and the open source GPS unit at the bottom.

tools and to enable communities outside the infrastructure to understand and engage with it, identifying possibilities for collaboration and service innovation. The GPS data visualizations and the video footage made the back-end information of postal infrastructure observable and reportable, offering a complete narrative of the mail distribution journey. Creating the tools, mining your own data and visualizing them provided a completely different experience from, e.g. simply watching a data visualization video animation. People without a whole view of the system like me had the means to relate to it and interpret it. Several qualities of the infrastructure have been exposed, making it possible to reanimate and materialize the figure and the logic behind its design and therefore relate to it. In particular what emerged is the image of an industrial infrastructure that is indeed efficient in performing its function, but designed according to standardized location-activity criteria that might be outdated in an age of pervasive connectivity.

Openings and limits of representations

The combination of spatial, "4Mails", and internal information, "Parcel View", allowed me to identify possibilities for new concepts of interactions between the service provider and other actors in the city. From my observations and interpretation, for example, location data and latent storage capacity in warehouses, post offices and delivery trucks captured could become sharable information and resources for local inhabitants and commercial activities, generating new forms of interaction and synergies. As a hypothesis, businesses and individuals with a need to move things locally could use these spaces when available, intensifying the use of existing available space when vacant and not completely exploited by the infrastructure. Similarly, using existing trucks already moving in the city could be a strategy to better use existing capacity whenever possible. Such information could eventually be made available through peer-to-peer platforms (cf. Hodson 2013) and meta-search engines specifically supporting delivery services. Such systems could be useful, for example, to support emerging locally based production systems and their new supply and distribution needs e.g. local farmers, fab labs and micro factory studios; or the creation of local service ecologies.

However, this is not sufficient to prescribe action. To understand how to meaningfully apply these ideas in a non-prescriptive manner, a deeper understanding of the context, communities and their practices is necessary. A single interpretation of our visualizations from a designer's perspective is not sufficient to prescribe changes and inform the design of new interactive systems. Thus,

the methods and tools discussed here must be included in an iterative design process including a dialogue involving key stakeholders and delivery operators. Multiple communities of practice inside and outside these systems would have different interpretations of the infrastructure and its possible representations, as well as different opinions about the impact of a certain technological solution or what degree of transparency and flexibility would be suitable and acceptable in specific contexts.

These tools alone do not provide any profound insight about these different perspectives, which are fundamental for any final design implementation. But being aware of these limits, hacking through probes, revealing and visualizing information can be used to develop the design materials we need to initiate such processes and conversations by means of triggering people's creativity. As such, this is design with a critical intent, where the primary purpose is not to solve a practical problem but to create the material necessary to start a dialogue between diverse groups of stakeholders.

Participatory hacking tools

Although our visualizations did not lead to any final solutions per se, the act of hacking creates a space for another set of considerations in relation to co-design methods and processes. In current product and service design development, users and designer are rarely aware of the organization and principles behind the design of the institutions and infrastructures that produced that context. Lack of knowledge might influence their ability to act on the foundation of infrastructures and limit the impact of their final designs. The design explorations presented here instead were aimed at increasing the transparency of a formal institution, ideally providing users with the necessary material to explore and re-think their forms and functions.

Due to their ability to make the underlying functioning of large-scale systems present and relatable, experiments such as the ones presented here could be included in a process intended to trigger public discussion and participation in the design and evolution of large socio-technical systems. In particular they could provide citizens with the necessary knowledge, materials and arguments to support their demands for more flexible and contextually adaptive solutions. An observation that raises some ethical questions about these practices, their politics and their possible use as tools to rebalance power relations and guide the transition of industrial infrastructures towards more citizens centered configurations.

The kind of 'hacking' used in theses experiments is not about destructive intrusions, but about learning, skill development and empowerment. Nevertheless, these types of interventions still expose some of the limits of industrial configurations and the fragility of privacy and control claims. In particular, in their simplicity, they illustrate how easy it is, with the proper knowledge and tools, to intrude into a system not meant to be publicly accessible. As such they offer a possible instrument to increase public influence on private networks. Nevertheless while opening up opportunities for innovation from the bottom-up, these practices might also produce consequences and rebound effects.

With technology always comes the possibility for hacking interventions, involving different kind of skills, depending on the sophistication of the infrastructure addressed. Once flaws are identified, services providers and network managers usually tend to patch them, using these arguments to justify their efforts and investments on increasing security, restrictions and control. Alternatively, hacks and bottom-up innovations are integrated within existing systems to provide solutions closer to customers needs.

This dialectic still characterizes much of the technology development process today: a set of problem solving actions and counteractions that do not seem to provide a sustainable strategy for development anymore. To break this vicious loop and the type of incremental innovation it creates, hacking practices could instead be employed as an instrument to facilitate companies and publics in the exploration of opportunities for their systemic re-configuration; as means to articulate controversies and discuss the possible effects of future design decisions.

Indeed, these initial explorations did not have the necessary depth to address this complexity or to produce any insight in this direction. Some of the questions and consideration they triggered however provided the starting for the other design explorations presented in this dissertation. For instance, the use of hacking practice as a tool to possibly guide the transition of existing infrastructures towards more locally adaptive configuration was further addressed in the second stage of this project, where trojanboxes have been employed in a 'participatory hacking' process with members of a small rural community.

2. Mid-explorations


MAYBERGS

Along with the exploration and development of the trojanboxes, a set of field work research activities have been carried out to practice and explore other ways to 'reveal' systems, allowing the creation of a more intimate knowledge and understanding of logistic, its workplaces, practices and technologies it involves. These explorations included interviews with managers and employees responsible for the local branches of global logistic companies, a whole day's experience on a van as a delivery man and a small design exploration aimed at engaging public on a discussion about peer-to-peer delivery services.

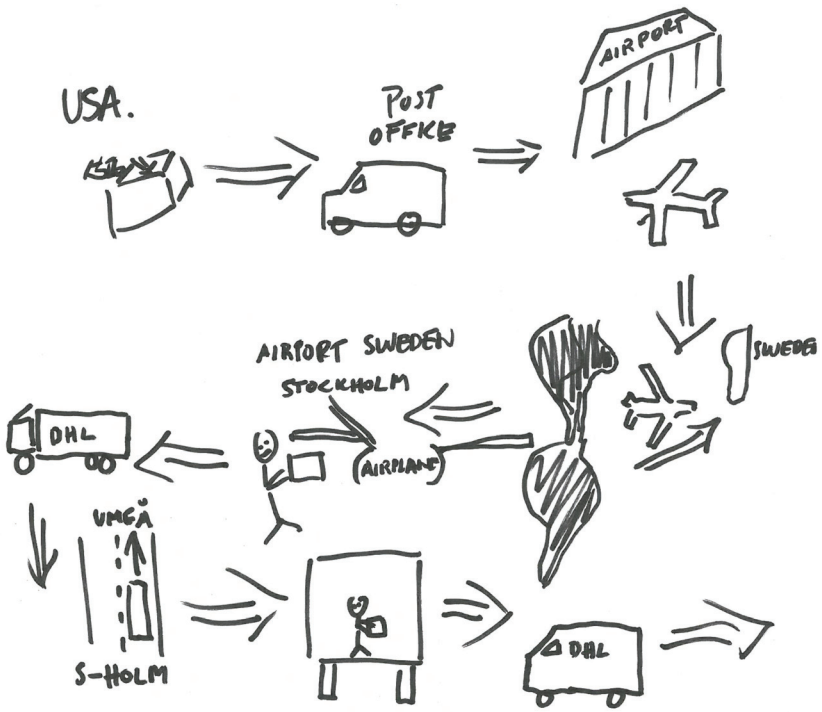
All together theses small exercise allowed me to have a better understanding of infrastructures from the perspective of those who work within these systems, allowing me to confirm and address some question and hypothesis develop through the hacking experiments. At the same time, the staging of a public design performance in the field allowed me to practice serendipitous ways of engaging with people in their every day lives and in an unmediated environment. The general lesson from these explorations is that while they do allow producing a type of systemic knowledge necessary to curate the introduction of new systems and technologies, they are not sufficient to provide re-direction. Traditional field research allows the designer to produce knowledge about a particular system its needs and interpretation of the world, while concept rehearsal in the field allows speculation about alternative concepts exposing them to a diversity of interpretations and uses. In both cases though, they still produce knowledge at the front-end of infrastructures, 'in or outside' existing systems.

Sketching interviews

After pursuing many delivery companies, in the fall of 2012 I managed to schedule a series of visits to a local private logistic facility. Special permission had to be first issued by their national headquarters and non-disclosure agreements had to be signed before the visit could actually start. In particular this concerned the impossibility to take pictures of certain areas of the building and share them. Limitations systematically evaded due to the particular interpretation of my work as a 'research-intruder' rather than a visitor and the necessity to document and produce material for design. All the different environments and procedures I was shown were the same captured through the videos in the hacking experiment. Nevertheless, through the visit a more detail account of how the different activities were accurately organized and optimize for maximum efficiency and the kind of technologies used to support them.

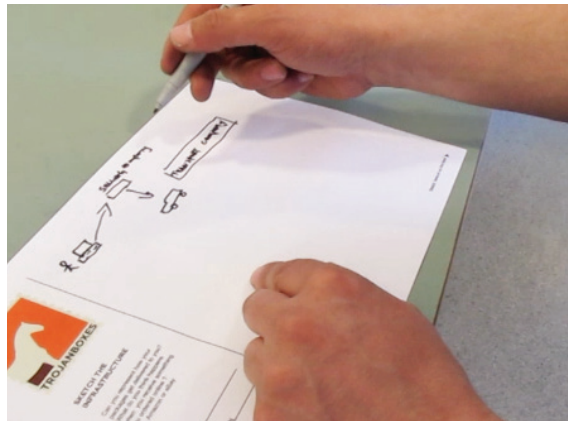
Long distance trucks and delivery vans journeys are organized as a railway system, connecting and serving particular locations and hubs according to specific time-tables. Accordingly, warehouses are organized as train stations where pallets and activities are grouped around the specific loading/unloading terminals where trucks going from or to a certain destination dock. For each type of vehicle a maximum capacity is set a priory. This space is then virtually filled in advance through the electronic labels containing the shipment information completed by customers before shipment. All this procedure and the different transactions of a parcel from one activity and location to another are managed electronically via computer databases. All workers involved within the service supply are equipped with a handheld device (PDA) equipped with bar code reader, GPS and wireless connectivity to scan and keep track of the parcels and to assist them in their work. For instance, drivers use the same device to manage and schedule all the different pick-ups and deliveries. One of the consequence of this optimization of assets and resources, as emerged in one of the conversations, is that during peak time such as Christmas holidays, when demand exceeds capacity, is the fostering of a market of private trucks owners, to which logistic companies subcontract when in need. Compared to official drivers these self-employed ones do not have fixed salary nor rights, conditions that induced them to drive for many hours, accepting as much work as they can, and thus increasing risks for their safety and for the other drivers.

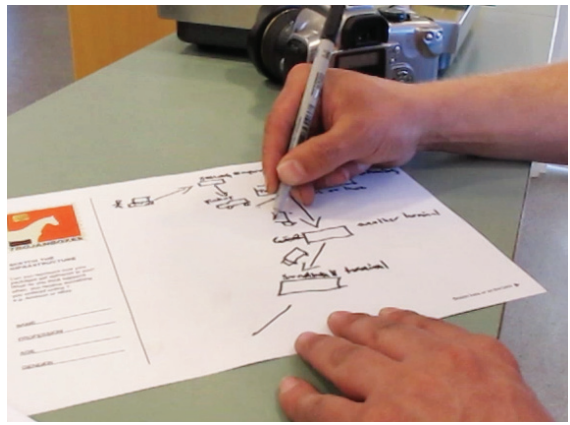
Along with the visit I conducted a series of brief interviews with people employed at different stages of the logistic chain, managers drivers, warehouse personal and so on. I asked them to sketch and describe how the logistic network works. Interestingly, all of them provided very different representations of the logistic network in which they were working according to the position they were occupying. For example, while the managers represented their network through diagrams made of boxes and lines; warehouse employees instead emphasized the activities at logistic nodes and warehouses while drivers represented a network mostly through airplanes, trains and trucks. A set of different interpretations and understandings of the same network confirm what could be already found in literature about systems' work representations as "artifacts constructed from particular social locations and within specific forms of practice" (Suchman 1995). Through the dialogue initiated by my action, different insights about their interpretations and my interpretation of the same infrastructure emerged, allowing me to have a better picture of the whole system and its meanings (cf. Pask 1975).



Sketching interviews: representation of the system's operation made by one of the truck drivers.

Facing: the sketching process and infrastructure's description by one of the warehouse managers. If in the driver's visualization vehicles are dominant in this second one, information flows seem to prevail.


TROJANBOXES



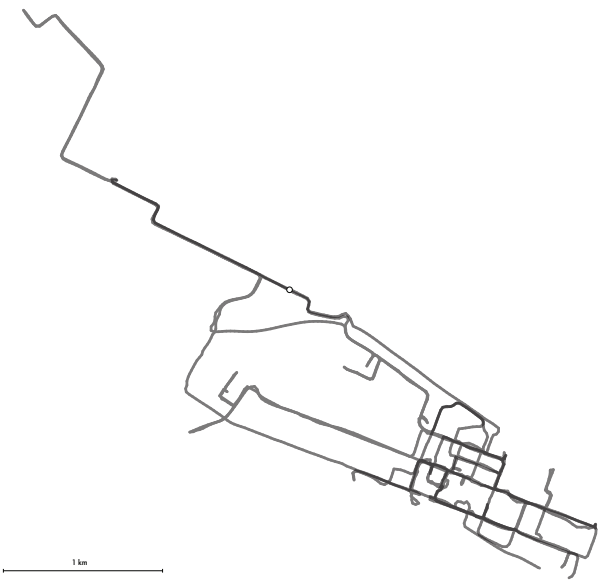

DHL Paket
Paket

Delivery man

Another type of field research activity saw me spending a day with Sebastian, one of the delivery van drivers for one of the main delivery service companies in town, and a local subcontractor for the global logistic company DHL. The purpose of this activity was to further explore some of the observations that emerged from the hacking experiment about the possibility to use location and van capacity information to support alternative ways to interact with vehicles and delivery systems. For this I had been logging the delivery paths and locations of the van through a GPS device during the day while taking pictures of the latent capacity inside the trunk after every stop. These activities where necessary to produce the kind of information required since, according to delivery company, labor unions in Sweden do not allow fleet owners to track their vehicles for privacy reasons. At the same time, retrieving information about volumetric capacity would have been hard since this information is concealed within the company's IT system and not directly 'queryable'.

Maps of the morning deliveries and afternoon pick-ups have been produced together with a representation of how the vehicle load varies during the day. This material has been used to engage Sebastian in a conversation about how to possibly use this information to improve this work. The maps and photos produced several topics and insight about his work and practice emerged, ranging from issues concerning the driver's need for support from parcels receivers at the moment of delivery, to policy and planning of freight distribution in town. For instance, a matter of concern for Sebastian was the effect of congestion reduction policies, as they do not allow delivery trucks to cut across the city center for their deliveries, thus forcing them to consume more fuel and produce more CO2.

The photos produced highlight a constant availability of hauling capacity during the delivery day, information confirmed by Sebastian as a general tendency during the year, with some rare exceptions. The material then allowed us to speculate on possible concepts for future delivery systems, where information about delivery paths of vehicles could be shared in real time with citizens as if they where subway lines, allowing them to intercept and coordinate with them to send things around the city. The idea seemed reasonable to Sebastian, nevertheless he pointed out how this would need to be tested to access how this could really work in the daily life, including user feedbacks and other drives. In addition, he noticed how most of the time he does not really follow the order



Delivery man: vehicle's latent capacity variation during the day and its delivery paths. The driver organizes the loading space according to delivery and pick-up activities that take place, respectively, in the morning and afternoon.

automatically generated by the IT system for him and displayed on his PDA, but he prefers to print it and readjust their order by himself since his local knowledge of traffic and roads is still superior to the abstract one of computer programs.

Carry me home

The third and final mid-exploration was a quick design intervention, planned and prepared in two days, which allowed me to practice with design-led field research methods. A small public performance and design game was set up as a way to practice with ways of engaging with publics through design performances in the field. For this purpose, a possible collaborative peer-to-peer delivery service in the city district of Ørestad in Copenhagen was mocked-up as a way to invite local inhabitants in a conversation about the opportunities of concept for their community and its possible issues.

Different parcels with different aesthetic properties, tasks and destination have been crafted and used to engage people in a conversation about the qualities of such services. Some of them where making noises, some others required to share their carriers to share their location, other to be left in refrigerated places. A small stand was improvised in front of a local mall first and a subway station, inviting people to delivery parcels for their fellow citizens offering an apple as a reward for their effort. After choosing one package, participants where invited to send me a picture of where they left the parcels and a comment about their experience. The performance lasted several hours, engaging with a total of six people collecting a very diverse range of opinions and interpretations about this possible collaborative system.

Through this type of intervention several issues concerning privacy, trust, safety and possible rebound effects of this type service, allowing me identify a few different qualities, contextual factors and circumstances that can affect people willingness to carry something for someone. The experiment offered, in this sense of the variety interpretations and divergent perceptions individuals can have about this possible solution, according to their specific experiences and needs. Thus it would provide a good starting point for researching how to design and possibly curate the integration of this system. The most valuable insights I've got from this experience however were about the methods employed and to articulate some of its qualities and limits.

Carry me home: participants with their parcels at the improvised peer-to-peer delivery stand by the Ørestad subway station in Copenhagen.

The imagined designers' plan of an envisioned system is often different from people's interpretations, their everyday life experiences and world-views. By allowing them to randomly encounter a design during their every day life routines, it becomes a way to expose a concept to its future environment, allowing it to talk back to the designer. Different factors and interactions that can influence and affect a possible design become visible, helping the designer to identify what practices this new system can support, its possible limits and misuses.

Compared to traditional studio work or arranged ethnographic field researches, this way of interacting with people is more difficult to control. Here nobody acknowledges or recognizes your presence and role as designer but conversations and events occur randomly and in ways that are not always easy to record if working alone. There is not an *a priori* agreement or client-designer relationship. Participants are not expected to work with you to the resolution of a problem. Actually there is no predefined practice or use to address from the beginning, but these emerge from the field through the interactions among people, context and design materials. These works are suggestions and provocations that allow people to think about something out of their comfort zone and relate to something they did not experience yet.

The aesthetic qualities of the parcels also played an important role. Parcels with a more recognizable aesthetic appearance and better articulated tasks and games where those thought to be more fun and engaging, resulting in being the only one that produced interesting information and whose tasks where fully carried through by their carriers. Thus, while, indeed design research artifacts need to leave space for unexpected uses and interpretation, qualities, questions and performances of a design probe and tasks need to be well defined and articulated to engage and persuade people to take part in a public design experiment with no predefined arrangement.

A final consideration about this experiment is that it exposed the relationships between the design of new alternative, bottom-up and collaborative systems with existing industrial networks of infrastructures. Despite being innovatively social and sustainable, these types of design interventions remain at the front-end of infrastructures, as such they can produce new niche systems that can eventually grow and perhaps be incrementally integrated into existing ones. Without informing how to sustainably integrate these systems into the surrounding infrastructures creating new synergies and interoperability with other logistic actors we will not be able to develop sustainable ways of providing city logistics; but we will keep contributing at the production of new standards and infrastructures.

3. The drone postbox


POST

The drone-postbox is the basic unit of a speculative design for a distributed delivery network in the Swedish countryside performed by drones. The system has been designed in response to certain properties of existing logistic networks in an area that is currently poorly served by existing services. In relation to the overall purpose of this experimental design, this little red hut does not represent a 'solution' or final concept, but just one possible materialization, as a kind of rhetorical artifacts, developed to support the staging of participatory design processes with local communities and stakeholders.

This concept is the result of series of collaborative explorations of logistic infrastructures conducted with the members of the small community of Floda in northern Sweden aimed at understanding how to possibly make existing delivery services serving area more adaptive and supportive to local needs (Davoli and Redström 2014). The abysmal level of logistic service experienced by the residents of Floda, as well as the rather unique conditions presented by this remote context, provided an interesting site for exploring current challenges and opportunities in relation to logistic infrastructure. It also provided a concrete 'last mile distribution problem' case study that allowed us to consider how logistic networks might better respond to local needs (Davoli, Wiltse and Redström 2015).

A set of trojanbox sensor probes was crafted and employed in a participatory hacking approach to trace and materialize the back-end operations of logistic networks, making them available for a kind of design intervention they were not meant to allow for. As a response to the results of this initial exploration, the second stage of this process was to enrich the material available for discussion by means of suggesting and staging new design possibilities, such as through the creation of the speculative system of a local delivery system based on drones described below. A delivery drone and a drone-postbox were prototyped and used to stage participatory processes of experimentation, initially in the studio and then later in the field.

Here, I will first describe of the design process that led to the design of this speculative material up to the point where the more extensive participatory on site experiments can begin. I will then provide and account of such field intervention and rehearsal of a possible drone operated logistic network in Floda and how, through this activity, I was able to gain insights into the specific needs of its residents — assessing their attitudes toward the rather unconventional system

proposed as well as enlisting their help in imagining how such a system might work and serve this particular community well.

Tracing and probing

During the development of the trojanboxes and exploration of their use, Richard, the owner of a small architecture firm located in Floda, became interested in my experiments. A reason for his interest was his dissatisfaction with how excluded and poorly served their location is by the main logistic and delivery services. Richard's firm is an example of micro-factory where small design productions take place and the shipping and supply of small quantities of materials, parcels and tools are fundamental for it's activity. However, serving such a sparsely populated rural area is very expensive for companies, resulting in discrimination in access to logistic services for the local inhabitants compared to their fellow citizens living in urbanized areas. This, in turn, requires people to drive long distances to retrieve their parcels at the closest pick-up point.

We therefore agreed to set up a first experiment with him, and to build a set of boxes to allow the members of the firm to trace and reveal the underlying processes of the three main logistic companies in the area as they make deliveries from the city to their location. In addition to the trojanboxes, a cultural probe approach was adopted as a way to gather insights and ideas not only from the infrastructural side, but also from the users' everyday activities and interpretations of these infrastructures. Activity logs for noting reflections during the experiment were provided to the two owners and main residents of the firm, while cellphones and social networks were used to collect photos and anecdotes from them and learn a bit more about their context and practices. For instance, besides complaints about driving long distances in cold and snowy weather conditions, we discovered that an informal collaboration and peer-to-peer delivery system was already in place. However, the low population density and distances between buildings and local dynamics make it difficult to coordinate and make this solution reliable.

Due to the long distances between the firm and the drop points, we shipped the packages (all weighing less than a kilogram) using the cheapest fare for each service, while participants were invited to follow their travels online and explore their content after picking them up. Using the maps and videos as records of what was happening at the back-end of the three delivery services, we were

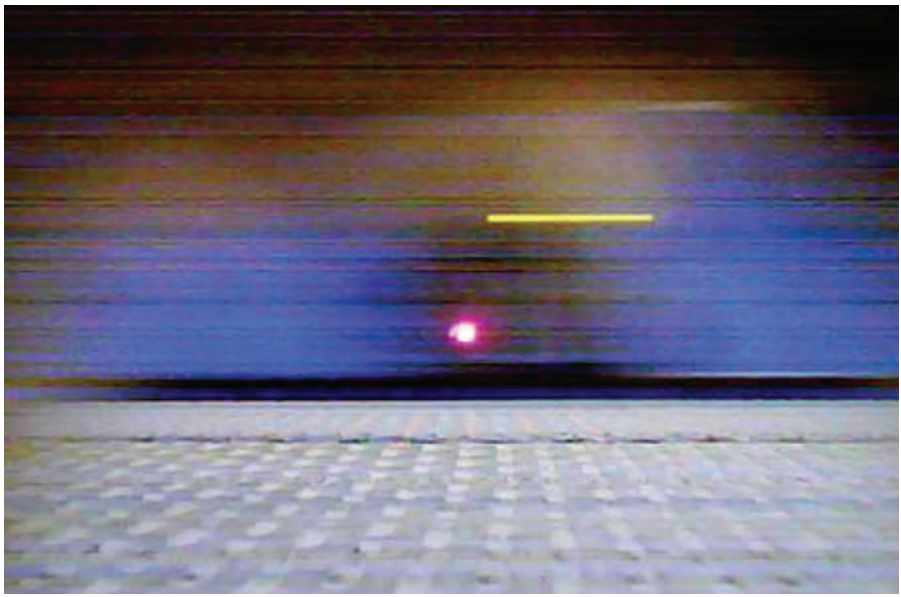
able to obtain stories of the distribution journeys and how work seemed to be organized. Of the three services, only one delivered at the door. The other two required the receiver to pick up the parcels at local nodes at a distance of 26 and 46 kilometers respectively. One unexpected result was that one of the packages travelled 634 km south before going back again, to reach its destination 67 km north of where it was shipped.

The probes inspired both the participants of the experiment as well as us researchers to explore the information gathered and to start to tinker with possibilities. Through the experiments, several qualities of the networks were exposed and different opportunities for design emerged. For instance we were intrigued by the latent hauling capacity that delivery vans occasionally seem to have and that our cameras captured. However, inspired by the maps and the augmented connectivity offered by our experiment, we collaboratively decided to focus the next stage of our design exploration on the gaps between what existing networks cover and what the community needs. As a response, we sketched and mocked-up a concept for a local and community-owned mesh infrastructure operated by drones in synergy with the infrastructures in place, so as to avoid proliferation of services.

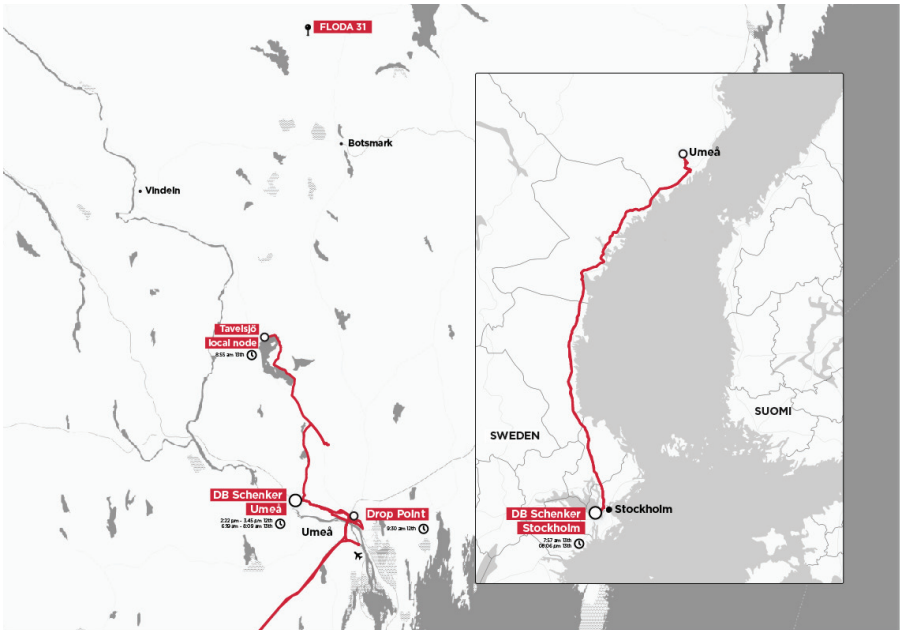
Tracing and probing: trojanboxes, cultural probes and pictures from social networks shared by participants. These materials were collaboratively employed to hack and explore logistic services, and to gain an insight into the participants' every day lives and interactions with logistic services.

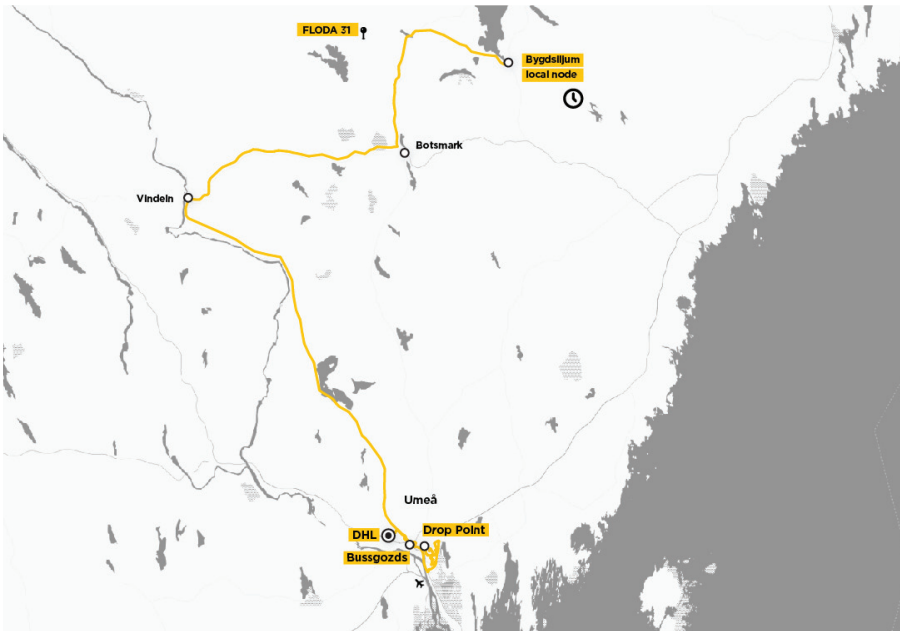
This kit provided a playful way to engage participants in a discussion about an otherwise mundane infrastructure: *"Could not resist looking at the footage, looks good too!"* a participant commented via email after receiving one of the trojanboxes.

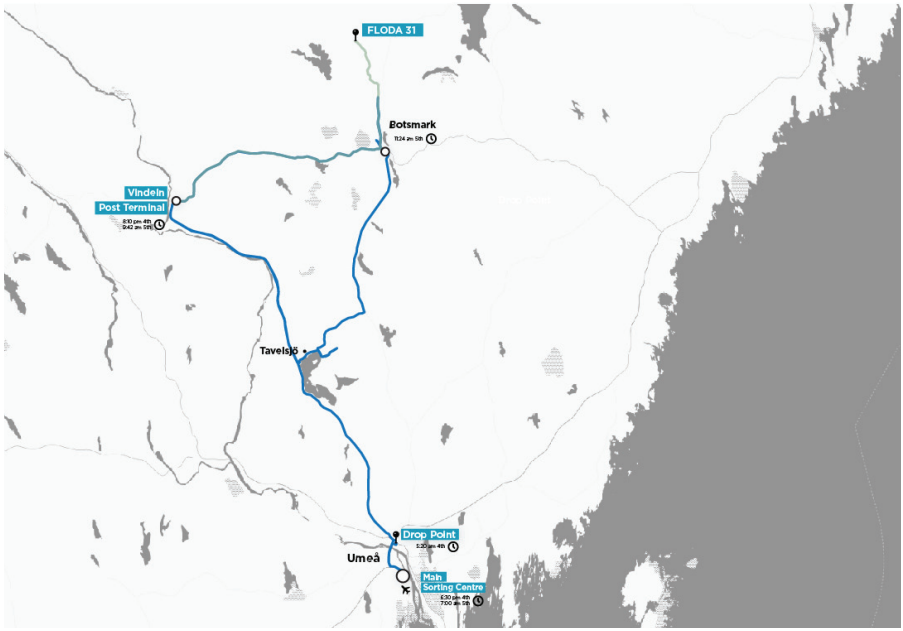
Tracing and probing: evocative snapshots and portraits from the hidden world of logistic as captured by the probes' cameras.



"The delivery van was half empty, how is that efficient?" a participant wondered after looking at the video material.


FLODA 31
Botsmark
Vindeln
Tavelsjö
local node
DB Schenker
Umeå
Drop Point
Umeå
Umeå
SWEDEN
SUOMI
DB Schenker
Stockholm
Stockholm


FLODA 31
Bygdsiljum
local node
Botsmark
Vindeln
Umeå
DHL
Drop Point
Bussgozds



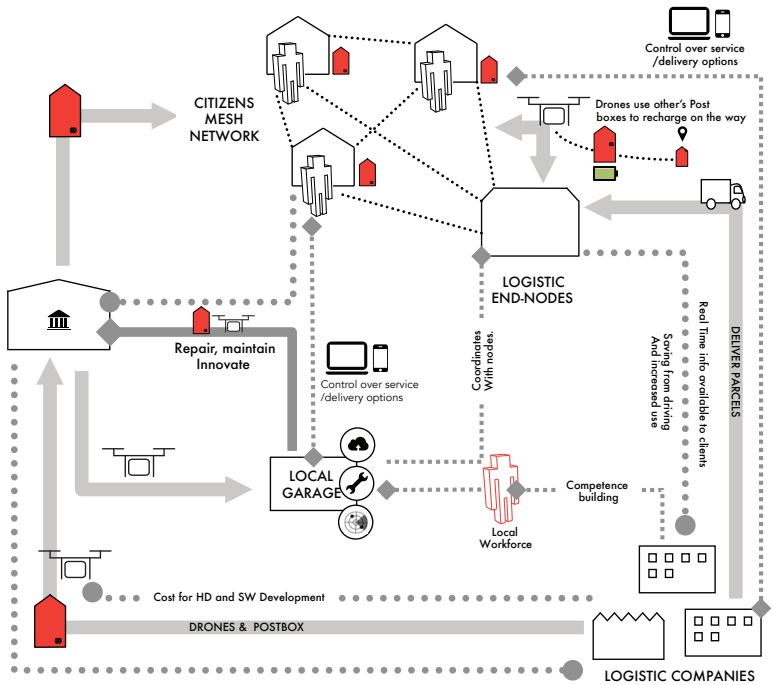
Tracing and probing: the maps of the three delivery companies serving the area. Only the post in blue, being a former public service, still provides door-to-door delivery. This implies higher mileage driven and running costs compared to the competitors. The company in the top-left instead, in red, finds it more efficient to ship the parcels south to their main node in Stockholm before reaching the north again.

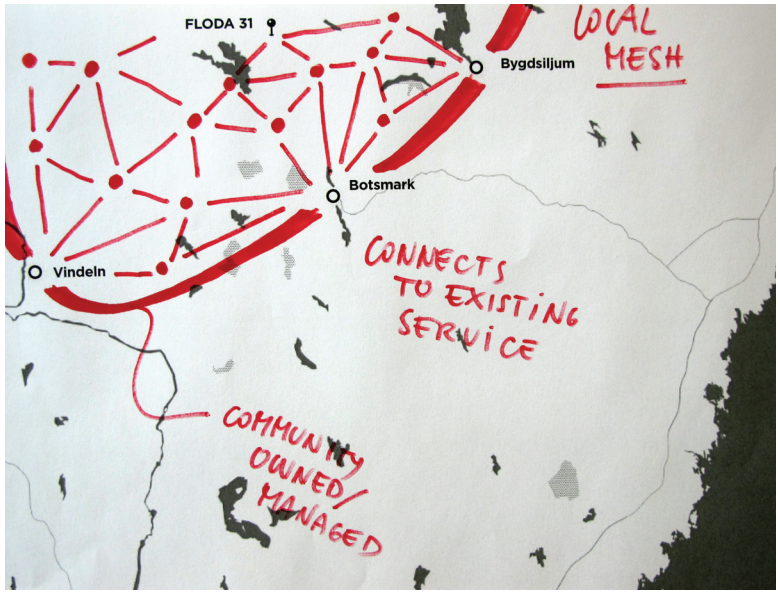
A transtructure model

The basic idea behind this concept is that of making citizens to become the essential nodes of a network where unmanned aerial vehicles would take the responsibility to deliver and connect different houses to the closest logistic terminals. Through partnership with existing logistic service providers, communities would lease the technology and handle maintenance and management. In exchange, the companies would use the new local infrastructure to, for example, provide door-to-door services at lower cost then ground transportation. Members of the community would do their part of the network implementation by placing a drone-postbox on their property allowing drones to recharge along their journeys in this very sparsely populated area.

This is how a possible description of this service might sounds like: A drone picks up a parcel from a local logistic node — Usually convenience stores located in the bigger villages in the area — After flying tens of kilometers over forests, fields, and lakes it finally arrives to destination and delivers it to its recipients via the drone-postbox. In the center of this partially enclosed platform is an opening into the large box below, and into this the drone drops the package it has been carrying. In the meantime, elsewhere, a small local business ordered a pick-up too. After placing their goods in the drop box, a drone quickly comes to retrieve it, conveniently allowing the local firm to ship their products through the global logistic network. When the distance to a particular destination becomes prohibitive in terms of battery capacity, drones can stop at any postbox within the network that is on the way to recharge and hand off the package to another drone to complete the delivery. By placing a drone-postbox on their property citizens help not only themselves through enabling this much easier method of receiving packages but also everyone else in the community who relies on the service. Once better defined through sketches and service systems maps, I started to explore ways to express this system concept and give it a presence.

Facing page: the system map and sketch of the community-owned, drone delivery network concept, based on the materials produced through the participatory hacking session.


Control over service
/delivery options
CITIZENS
MESH
NETWORK
Drones use other's Post
boxes to recharge on the way
LOGISTIC
END-NODES
Repair, maintain
Innovate
Control over service
/delivery options
Coordinates
With navex
Saving from driving
And increased use
Real Time info available to clients
DELIVER PARCELS
LOCAL
GARAGE
Competence
building
Local
Workforce
Cost for HD and SW Development
DRONES & POSTBOX
LOGISTIC COMPANIES


FLODA 31
Bygdsiljum
LOCAL
MESH
Botsmark
Vindeln
CONNECTS
TO EXISTING
SERVICE
COMMUNITY
OWNED/
MANAGED

Exploring expressions

As a reference to the typical traditional house of the region, we based the basic form of the drone-postbox on the shape of a small red hut. Our intention was that this quite generic, but still distinctive, appearance would allow people to use it as a basis for interpretations turning towards both the familiar as well as towards the more speculative. The motivation behind this stylistic choice and not other, is that if people change their practice on the basis of the style they already have, I needed to use a form and aesthetic that would all possibly share and recognize as something belonging to them and their community in order explore both their present world views and attitude toward adopting new practice styles (cf. Tonkinwise 2011). Being the regional aesthetic possibly one of the few thing the local inhabitants — who vary in terms of education, work, values interest etc. — would all equally appreciate we started to explore some of the qualities of this kind of form and aesthetics.

As a form experiment in this direction, with the help of Johan Redström as a photographer, we produced a series of photo sessions where we tried to bring forth aesthetic qualities related to both the more traditional and the more 'sci-fi' through different kinds of daytime, nighttime and staged indoor images. These sessions also worked to enact situations of use, as well as to shoot the images we needed to create a service interaction storyboard for our collaborators. Exploring the aesthetics and expressions of the 'real' (as distinct from, say, digital image manipulation), we only worked with available light. For instance for the indoor images we used large-scale projections in a studio to stage and shoot imaginary scenes of what using the service could be like.

The postbox and its drone where here used as to actively play and collaboratively discuss possible scenarios 'on stage' and produce a set, of slightly unstable, perhaps unsettling images, working with the opposite of much image manipulation as only the new objects are 'real' and the rest is just a projection. Working with images with diverse aesthetic directions, we were hoping to increase the chance of destabilizing immediate impression that there is just one way of looking at this, and instead inspire a range of interpretations. These images have been then printed and included in a set of field materials used to introduce and present the whole project process and concept to the inhabitants of Floda.

The drone-delivery system's mockup up: although distinctive, the shape of the drone-postbox is still open and 'in the making'. It is the research material to explore a concept and system that are not defined yet.

Gloomy days are the norm in Sweden. Exploring the aesthetics qualities of a product that will likely spend most of its time in these weather conditions is therefore relevant to understand what this artifact will look like in the everyday life settings in which people will use it. The resulting effect is probably less persuasive than the other sci-fi images, intentionally crafted to captivate and trigger imagination, but definitely closer to reality. Because of this divergency in aesthetics properties, these two sets of portraits open up for a variety of interpretations and possible evaluations about what the future service can be.


POST


drone takes off fr m
a local node.
POST


drone comes
to deliver
package

Rehearsal of a service interaction storyboard in the studio. The different stages of the service were played in the studio as a way to collectively explore this possible scenario and produce material to present it. This type of performance can be useful in the early stage of the design process as a means to collectively prototype service interactions and uses and possibly anticipate some critical aspects requiring further attention.


drone takes
flies to anot


off and
her house

Speculation in the field

In the second stage of this process the delivery drone and the postbox have been used to stage participatory processes of imagination experimentation in the field using these artifacts as a mean to explore this possible future configurations. The staging and rehearsal of this speculative delivery system took place in form of an impromptu public performance. This choice was dictated by the attempt to bring the experience of the future infrastructures as close as possible to everyday life, making its future users seemingly encounter it without setting pre-defined events or the workshop, which might bias its perception and interpretation.

The scene of this design performance were the scattered houses along the sixteen kilometer stretch of road that connects Floda to Botsmark, the main village and most accessible logistic node of the area. The actual staging occurred on April 25th 2014 and went on from approximately 11am to 5pm. The research team was composed besides myself, of my colleague, the technology and design theorist, Heather Wiltse and Tommy, a local participant who helped us as translator. To introduce local inhabitants to our concept and to the whole project process to the inhabitants of Floda, we prepared by bringing with us two sets of fieldwork materials in addition to the drone and postbox prototypes. A trojanbox and a collection of images were used to illustrate the project process and communicate what previously happened in the first phase: from videos and maps of the participatory hacking sessions to the staging of a service interaction storyboard.

Setting out from Floda we stopped home-by-home, engaging people by placing the big red postbox in their front yards and simulating the arrival of a parcel by flying the drone around their houses when possible. Eventually we stopped in front of the local convenience store that serves as the logistic node in Botsmark. By the end of the day we had six encounters in total, which included engagement with both individuals and group, and people of different ages and cultural backgrounds. Each encounter lasted approximately forty minutes. The dialogues that emerged from them raised a number of broad and complex social, economical and technical issues. For instance, one dominant topic in our conversation was the antithetical relationship between current urban-centric development of liberalized and global economies and local development (cf. Graham and Marvin 2001). However, while the effect of processes such as globalization or industrialization often result in difficult to grasp and practically understandings, through the tales, interpretations, and analogies of the participants and in their settings, suddenly these became relatable and relatively simple to unfold.

The road between Floda and Botsmark was the scene of our 'wondering design encounters'. Using the drone and its postbox as stage material, we enacted the arrival of a parcel. This allowed us to engage local residents in a discussion about logistic evolution in relation to the area, as well as to speculate together about the drone-postbox system and its qualities.

Wondering design encounters

Local economies and employment: Our first stop was at Floda31, the small architecture firm owned by Richard, one of the participants in the initial participatory hacking process whose challenges as a small business owner had also provided much of his motivation. Here we staged our first performance as a way to show Richard the results of our work and to introduce our translator, Tommy to the project, unloading the postbox from the cargo van and flying it around the house to evoke the idea of a package delivery. Richard watched approvingly from his balcony as the drone flew over the valley. It was a rather unusual sight but one that, for him, suggested the possibility of better logistic support for his own business and perhaps the inception of others in the area. Tommy started to ask questions at this point, and in answering him we used the images and materials we brought to illustrate the motivations and process behind the concept. From the video snapshots captured by the trojanboxes, he recognized some of his former colleagues from when he worked in the local post office of Vindeln, one of the main sorting centers for the area. Some time ago, the person he recognized in the images had migrated to Norway to work in a big sorting center close to Oslo. The observation provoked reflection upon the lack of work opportunities for young people in the area who are therefore forced to move to bigger cities for employment. Tommy himself is in his twenties and unemployed and empathized with the scenario. He saw the drone network as something that could generate work for him and other young people in the area, who could have the chance to do meaningful work for their community in supporting the network by maintaining and modifying the drones.

Industrial criteria and accessibility: Lutz, a retired network engineer from Germany, also brought up differences in accessibility between cities and countryside. He compared his current situation with what he was used to when living in Mannheim, saying that in Germany it is normal to have packages delivered to homes; and when people are not home, packages are left with neighbors. In Floda, he said, it was not so simple. After he looked at the results of our explorations with the trojanboxes, he claimed he often questioned the power of private companies to marginalize certain communities only because they are not big enough to be "a market." However, he also felt somewhat resigned about the possibility to change this power relation. In particular he found it ridiculous how inflexible and standardized the protocols of these logistic companies are. He told us how the last time he received something from one of the main delivery firms operating in

Local economies and unemployment: Richard gets out on his balcony after hearing the buzzing of the drone approaching. In the meanwhile, Tommy, checking our field material, recognizes his former colleagues in one of the snapshot captured by the probes.

the area, it arrived at one of their main nodes in Tavelsjö, 46 kilometers away, so he asked if it was possible to send it to the closer node in Botsmark. To do this they first shipped the package back south to Stockholm. It finally arrived a week later after traveling more than 1200 kilometers because the company lacked the capability to transport it locally for 20 kilometers. Lutz therefore could clearly see the advantages of a small public infrastructure like the one we suggested, as long as the technology is reliable and can provide some economic return to the community. He was also really concerned about technical issues, noting the small size of our drone and asking about how this would limit package size. In response we clarified the speculative intent of our work and also explained the numerous technical possibilities available that were not manifest in the small drone we had with us. At his invitation we finished our conversation inside over coffee before packing up and heading down the road to the next house.

Publicity and pre-industrial connectivity: Bo is a retired tractor driver who used to provide services such as cleaning roads from snow or plowing a field. His first reaction to the drone and the post box was to take a picture of it. He seemed very curious about what we were presenting, and thought carefully before expressing his thoughts. Initially he raised some concern about the trust and safety of the system. As a private person he could not see any problem with it, he said, although he probably would not send any gold that way! He also raised concerns about how public the system would be, and what would happen if his neighbors could see how much he received. However, he said that local maintenance and management of the system could limit misuse of the technology in relation to issues such as privacy. When talking about improving accessibility, Bo told us that the area was not always disconnected, but that actually this isolation is something that happened quite recently: 40-50 years ago, the area around Floda had dairy production as a main source of income together with small scale farming, including selling local products and vegetables. Each farmer used to produce small quantities of milk that were then collected and sold to the local dairy factory and then to cities and villages. Because of that business, the area was well connected, with 3 busses a day transporting people and goods. There were schools then, he said, and children to fill them with! When the effects of industrialization and globalization reached Floda, however, this market was not sustainable anymore. Population dropped as people moved to cities and bigger towns. At the same time the infrastructure disappeared and with it the area's connectivity and accessibility to services. "Now there are only retired people like me!", he concluded.

Industrial criteria and accessibility: after a long conversation outside his house, Lutz invited us inside for a break. Here we could have a deeper insight on his life story and some of the reasons and motivations that brought him Floda, including its peace, nature and isolation.

Publicity and pre-industrial connectivity: while taking picture of this unusual 'thing' we were proposing to him, Bo started giving us an account of the evolution of logistic services in the area and its relation to production. With the centralization of production around cities and the industrialization of farming activities, the local economy based on small scale activities dried up.


POST

Re-Connecting People: Proceeding towards Botsmark, we came to a small cluster of houses built around a narrow strip of land in between two small lakes where we stopped and staged our scene. Two annoyed cranes flew away, disturbed by the noise of the drone's rotors as it flew over the lake. After a few minutes two women came out of their houses and approached us. The older one was Tove, the younger her daughter Karina. Tove used to own a shop by the road. Pointing to its crumbling foundations just down the road, she said the shop stayed open until there were not enough people living in the area to make it profitable anymore. She is now retired and lives alone in a yellow house just in front of where we stopped. Tove was quite excited about the delivery system concept, since currently she depends on family and neighbors for almost everything. She therefore saw in the system a means to become more independent, e.g., to be able to buy small groceries or, more importantly, medicines. Karina works in the city all day. She leaves early in the morning and comes back in the evening. She said she would use this system for having the newspaper in the morning. Right now newspapers are delivered late in the day and she can read it only in the evening. She would love to be able to read the news at the same time as someone living in a city. The two ladies were so enthusiastic about the idea of a public drone delivery system that they started to ask if it would be implemented and how much it would increase their taxes.

Safety and flexible designs: Arriving in Botsmark, we placed the drone-postbox and flew the drone in front of the local mini-market, which is also the main logistic node for the area. Our first encounter here was Pontus, a construction worker in his twenties, and his friend. One of their reflections was to adopt a system like this because of drivers' safety. During severe winter weather vans and trucks delivering in the area often end up in accidents, causing delays and, in some cases, even loss or damage of parcels and goods. Occasionally delivery vans also get robbed, they added, expressing also their doubt about how this issue could be possibly solved. They also suggested the postbox design should not be fixed and standardized, but that it should be possible, given the technology and some basic requirements, to build and customize it according to people's homes and needs. Pontus has a dog, and said that if the postbox were configured as the prototype, the dog would probably try to chase the drone. While saying goodbye to the two men, a woman named Eva stopped by to see what our discussion and the props were all about. She lives in the countryside outside Botsmark, and although she was in a rush she immediately understood the issues we were trying to address. It would be perfect for delivering her orders from Internet purchases, extending the flexibility of digital services into the physical world she said.

Re-connecting people: after flying the drone in front of their houses, Tove and Karina came to us asking what we were doing. We unloaded the postbox and used the research materials to illustrate and discuss the drone concept with them. The two ladies were very positive about it. But what if its implementation would affect their every day relationship?


POST

Safety and flexible designs: Pontus and his friend posing with the drone and the postbox after carefully questioning and criticizing its design. In their account they provided a interesting take on the need for customized and flexible solutions.

Eva who just arrived by car to pick up her deliveries, tells us how she would use the drone delivery systems. In the meantime, a small crowd were entertained by our conversation.


POST


VIKTIGT
ALL PARKERING
MÅSTE SKE PÅ
ANVISAD PLATS
POST

Changing perspectives Our last objective was to interact with one truly important individual for our speculative system: the owner and manager of the local shop and logistic node, Inge Marie. The shop was full of customers who naturally became part of the conversation since they saw us outside. Initially they were quite skeptical, laughing at the possibilities we presented, drone in hand. However, once they understood we were serious in our questions and that this actually could be a future possibility, they suddenly became more thoughtful. Inge Marie said that as long as one pays in advance for the service it would not be a problem for her; and since she had to sort and store packages for the different couriers in any case, it would not change much if she had to do it for a machine instead. However, watching the friendly scene at this small community hub by the side of the mostly empty road, we could not help but wonder if loading packages for delivery by a machine would not have more of an effect on Inge Marie's life—and the character of the community—than she or they could anticipate.

Reflections on the drone postbox

The insights gained from this set of design interventions described here calls for some methodological considerations about their ability to initiate and curate the transformation of industrial systems towards more open and locally adaptive forms and functions. Indeed any attempt at opening up an industrial infrastructure for a design intervention it was not intended for is, in many ways, going to have significant limitations. Nevertheless, the use of a participatory hacking process proved the ability of this particular application of sensor probes to provide an engaging and effective research tools. The trojanboxes successfully allowed participants and researchers to relate to logistic infrastructures, giving a presence and a form to all the different human and non-human actors that constitute these system, their operations, practices and locations, making them available for judgment and interpretation. In particular, through the probes the participants could build their own rationale about the systemic agency of logistic networks serving their area, and understanding their qualities and developing the necessary knowledge to conceive possible alternative solutions and compare concepts.

For instance, they were able assesses what could happen by only incrementally adding onto a single delivery network the ability to provide last miles deliveries with drones — such as their proliferation and inability to exert control over their operations — and how this would have been qualitatively different from the

Changing perspectives: Inside Inge Marie's store, customers look at the drone flying outside the store unwilling to believe what we were proposing to them. Through our conversation however they started to become less critical to the idea. Similarly Inge Marie, in between clients, started to give us her precious feedback about how she imagined the new system would affect her job. But would it be really as easy as she described?

community owned transtructure concept we developed. Peer-to-peer concepts were long discussed since they were already available in some way. However, it became clear to participants how a DIY local systems would have been also difficult to implement and hard to integrate with the standards and protocols of infrastructures in place and their need of control over the delivery process and its performance. It was through this reflection about the duality between top-down and bottom-up systems that it became clear to me and other participant how 'hacking' was not only a way of learning, but also potentially a way to address how to (re-)balance power relations between service suppliers and consumers. While hacking is a potentially damaging practice, it can also be used as a democratic instrument and a form civic contestation. By exposing opportunities outside the corporation's view and disposition through hacking, citizens are empowered with the necessary dialogical material to argue and claim in favor of one alternative instead of another.

A second set of considerations must be made about how the concept of a future Drone Delivery systems as the one suggested can be open up for a diversity of interpretations and collectively explored with people and citizens. The purpose of this process was not evaluating this specific solution. But rather, it was to explore what happens when something otherwise invisible is made tangible and present, using mockups as means of producing knowledge about the context and explore what a system with such distributed and glocal qualities could be. By performing, or perhaps rather rehearsing, a speculative service concept in the field, we opened up an opportunity to, for a brief moment, interface with networks we otherwise cannot access directly in the context of our everyday lives.

The field material became the point of interaction, literally a materialization of the *infra-*, between the global untouchable and un-relatable reality of industrial logistic infrastructures and a hypothetical new hyperlocal one. Through an open and active dialogue between the material, the context and us, participants were able to form ideas about these networks based on their particular individual interpretations, continuously shifting between present and future. At the same time, the staging of the speculative concept allowed us to probe into a community and its environment. This offered us an impression of what the collective experience and agency of a future infrastructure might be and, in a relatively short time, get a glimpse of the complexity of relations, attitudes and mediations otherwise difficult to sense. Connections between abstract theory and concrete reality continuously emerged, facilitating a rapid dialectic between situated and

systemic thinking. Contextual knowledge and history of local infrastructural developments and involution in relation to urbanization industrialization integrated and confirmed background generalized notions from literature. Through such a loop new possible crossover points between an envisioned system and a specific context emerge, allowing the identification of design parameters and criteria that are relevant when staging interventions with the purpose of enabling symbiotic relationships between local systems and global industrial networks.

Critical aspects and consequences of the suggested system requiring further exploration and prototyping emerged too. For instance, the material and imagery we produced embeds specific values and politics and it represents only one (perhaps positive) of the many alternative scenarios that could and should be explored. However, staging this design performance in the field also allowed non-trivial aspects to not really took in consideration before facing and experiencing them and rehearsing in the field. For example, experiencing the cranes flying away disturbed by the drone during the staging brought to the attention something obvious like the influence of this system on the local fauna. Similarly, Tove seemed quite excited about the ideal independency the drone solution could provide her. Nevertheless it also necessary to critically ask ourselves as designers how would this effect her social life; would her daughter and family visit her as often if the drone system would be in place? To answer and explore how to possibly address these kinds of questions, further iterations and prototypes could be crafted to expose the future users of the infrastructure to the possible consequences of its implementations, and eventually explore with them adjustments or alternative solutions.

4. Antenna

Given the positive feedback and results obtained from the participatory hacking session with the trojanboxes, I became interested in how the same approach would play out in a different domain and in relation to a different kind of infrastructure. Especially, since the inherently critical and speculative approach I developed exposed certain ethical issues in relation to privacy and data ownership, I aimed for a domain that would challenge such aspects further. Mobile and communication networks seemed ideal for this purpose. The increasing importance of continuously available digital services in today's economy and the growing public concern for online integrity in light of a series of events related to data interception and surveillance, indicate that there is more to the infrastructure for digital communications than meets the eye.

In the background session of this thesis —along with the description of today's postindustrial tensions— I illustrated how over the past decades we have seen the emergence of a new 'meta-data market' based on the generation of value out of people's everyday mundane interactions with mobile devices and applications. Typical examples include the use of contextual data to customize online advertisement or provide localized services by means of collecting the massive amount of data users produce. Practices that raise issues concerning privacy, surveillance, and legitimacy also call for a debate about the social impacts of this new form of informational capitalism in respect to labor and value production in specific geographical areas of the globe instead of others and its consequences on local economies. Despite the importance and implications of broadband networks though, many of us are largely unaware of how they actually operate, of the data they produce and the many purposes and business models they serve in addition to the basic communication services we identify them with.

As the urban planner and technological expert Anthony Townsend argues (Townsend 2013, 293-294), "If companies profits from the data generated by cities and their inhabitants, shouldn't the community reap a share?" In his view extending public control of the data produced by cities and communities could potentially drive the creation of new viable business models supporting the development of local networks and economies. In this context, he says, "community-owned broad band is one of the best investments a smart city could make" (2013, 288). By putting control over many aspects of broadband management under local jurisdiction would put cities in control of their nervous systems opening up opportunities for human and social development. "Community owned networks also render moot the struggle over two important telecommunication policy issues: neutrality, which seeks to prevent ISPs (Inter-

net Service Providers) from restricting user access to content and applications, and making internet access a human right" (2013, 288). These are a few central points he addresses about how to fairly develop new civics and appropriate legal frameworks around increasingly pervasive digital networks.

However, how to possibly open up these kinds of corporate rather than public infrastructures for bottom-up innovation is less obvious than it was with logistic services. Compared to inquiring into logistic networks, the revealing and materializing of broadband networks presents a much higher level of complexity due to their greater invisibility and technological sophistication. A truck moving around in the city we can observe in our daily life. In comparison, the way a mobile broadband network operates is completely obscure to non-experts, and inside access is basically limited to service providers and hardware suppliers. Moreover, considering the sensitive nature of mobile data and the power relations in place, how to do this in a way that exposes relevant aspects of the infrastructure as such, but that also somehow mitigates the ethical risks and complexity involved, is far from trivial. To enable a discussion about these matters and to explore if there are ways in which design may contribute to the democratization of broadband networks, I initiated an experiment and exploration of a possible hack into the data flows of mobile cell towers.

The 'Antenna' is a fictional device made for hacking into mobile networks. It was prototyped as a way to articulate issues and possibilities by rendering their content accessible for bottom-up innovation when no other option is available without serious legal and ethical consequences. Photos representing the fictional hacks have been produced as material for discussions about opportunities and consequences of this future possibility. The experiment was set up to make it possible to compare its results with the previous experiments with logistic infrastructures, where a 'real' hacking experiment was conducted producing real data, and to critically discuss the qualities of speculative hacking material as a way to work with sensitive systems without violating the individual integrity of data.

This material was not actually employed within participatory processes. Nevertheless, the results of this work offer a starting point for an open debate and reflection about what kind of prototypes and with what qualities can be appropriate to curate the re-configuration of such systems, and for exploring the consequences and opportunities behind future practices and technological possibilities. In particular it raises questions regarding the usefulness, or uselessness, of fictional-non-functional prototypes as generative tools to reflect on

design activities (cf. Lim, Stolterman and Tenenberg 2008), and for exploring and inquiring into design spaces otherwise not possible to scrutinize.

Hacking broadband networks

To build a 'device' for hacking into broadband networks we started to look into what data generated through passive and active use of smart phones can actually be made visible. Different example of campaigns to increase awareness about metadata markets and who different apps installed in personal devices 'spy' and generate different kind of information's about their users are available and precious — see for reference Brett Gaylor initiative "Do Not Track Me" where through clear and detailed story telling some important information about how this happened is conveyed to non-expert users (Gaylor n.d.). However, while this tells us something about the kind of data produced, it fails to give any idea about the scale involved and geographical implication of their agency. To start engaging with the issue of scale, also physically, when it comes to 'big data' my attention instead turned to the mobile masts and cell towers that populate the landscape of our cities and countryside.

A key idea and reflection behind this interest was that if information and communication technologies changed the relation between scales, activities and space, by separating and redefining the relations between communities and places (Mitchell 2003), then revealing them could become part of the tactics for reconnecting digital activities and physical space. More specifically, allowing citizens to re-appropriate their own data could work as a catalyst for further explorations aimed at the design of contextualized services in support of local economies and the redefinition of the private-public relationship (cf. Dunne 2008; cf. Haque 2002). For instance, by knowing the use and load balance of a given cell tower, citizens could use its latent capacity to support ad-hoc local applications and meet contextual needs. Similarly the data produced and consumed at a specific node could help identify emerging opportunities for local services according to their content and connections with other communities and places. Such an approach would also introduce perspectives in contrast to the prevalent inequalities of value distribution and power relations that these networks and the applications they support create.

The idea of using mobile data for service design and urban planning is not new, and there are numerous examples of how aggregation of anonymous mobile

data can be used to create new design opportunities (Eagle and Pentland 2006; Grauwin et al. 2014; Rojas, Kloeckl and Ratti 2008). However, the design examples presented are still typically top-down in nature, primarily analytical in their scope, and not really intended for participatory purposes. In particular, they do not reveal what kind of data all third party applications actually produce, and what such stakeholders do with them. Considering the sensitivity of this material, I first unsuccessfully tried to obtain this information in anonymous and generic form directly from the service providers and companies providing the hardware infrastructure. Interestingly, specialists confirmed the presence of peculiar and controversial information in the use patterns of antennas and the active-passive production of private active-passive data. However, they also stressed the strategic importance of this data for the companies involved in this particular sector and value chains and the impossibility for them to share any information or generic properties of such data without violating legal contracts and business agreements between stakeholders.

As a consequence of this limit in access to information, I started to look towards activist practices to find out that the technical possibility to hack and stalk mobile devices already is something more or less readily accessible to anyone. CreepyDOL, for example, is a cheap set of devices able to wirelessly track the movements of mobile devices and collect private information from the apps they run when connecting to Wi-Fi hotspots (O'Connor 2014; O'Connor n.d.). This device has been developed for intelligence and is theoretically limited to private use for the moment. The availability and relatively easy accessibility of devices like this on the market raises interesting questions about their potential consequences for privacy and security. At the same time, it makes it technically plausible to imagine how mobile cell towers could be hacked, opening up options, questions and choices regarding security and control of data streams, consumer education and awareness, property and use of private data. To start exploring such scenarios and begin to create design materials for discussions and debate, filtering information about this design space, I decided to materialize this possibility through a fictional and non-functional prototype, the first Antenna.

Device and portraits

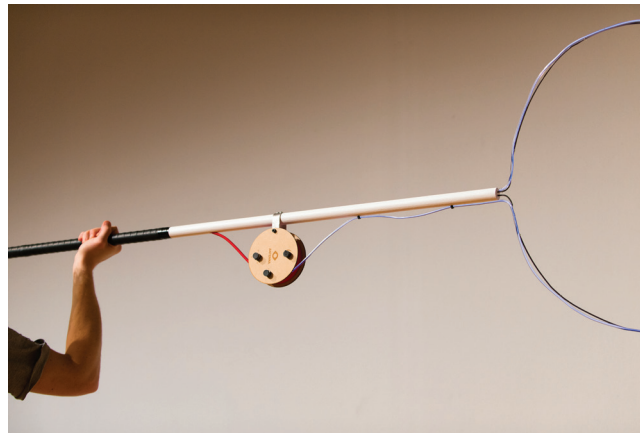
A blinking led connected to a piece of metal wire ending with a loop are the basic components of the simplest do-it-yourself electromagnetic meter. Antenna basically shares the same design, here translated into a new fictional purpose of

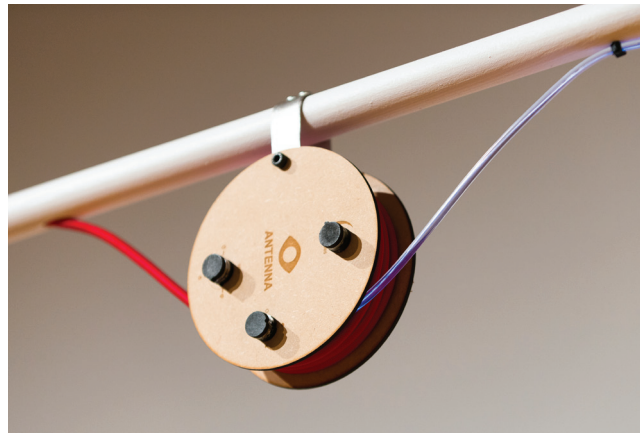
use. In terms of aesthetics, it is plain and slightly unrealistic in order to avoid it to be mistaken for a real device, at the same time leaving space for imagination.

The main element of Antenna is a rod supporting a loop shaped receiver that senses the broadband spectrum and extract its content. Attached to it there's a reel with different knobs used to change parameters and size of the antenna loop when searching for different frequencies, signals and data types. Through a cable, the rod is connected to a touchscreen used to visualize and analyze the sensed data and display information about the schematic of the hacked Antenna. Screenshots showing different kinds of information that can be retrieved represent sketches of an interface to data production and the invisible behavior of the broadband infrastructure. For instance, these sketches show how one can see the ratio between passive tracking and active data produced by social networks, interrogate the antenna about how much data is used for pornography, advertisement and applications running in the background, or to simply check the latent data capacity at different times.

In collaboration with Johan Redström, we used the device to stage and take pictures in the field and in the studio to document various use scenarios and create visual material to be used in future discussions. The main series of portraits depict a hacker hiding in a sort of "Faraday Poncho" using his Antenna to inspect and download data both in urban and forest settings. Another set of pictures depicts a screen placed at the base of a cell tower. These images show a scenario where the service provider has decided to open up its network for new innovations, here providing a direct interface for inspecting the data content of the base station, offering an application programming interface (API) for public use.

The aesthetics of these pictures is meant to place them somewhere between the familiar and the fantastic, ideally being both inspiring and unsettling. Some of the images were taken in a studio, using projectors to display the same background site as was used in the outdoor photos. To work with expressions somewhere between the real and surreal, we used projectors to project images from the outdoor location in the studio images but without any image rendering or compositing. The intention in doing so was to try to evoke the creativity and imagination of the observer, but also to work with something in contrast to the aesthetic of much design (research) imagery where 'things' become more or less equated with 'products' (cf. Dunne and Gaver 1997). Representations and aesthetics that inevitably would narrow down the spectrum of questions and





The Antenna device.

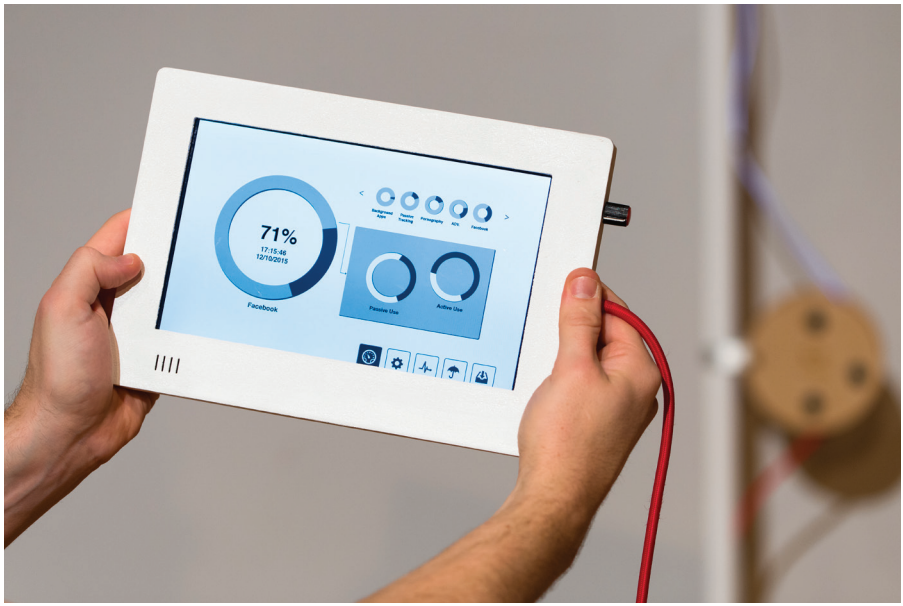
reactions of the viewer to an evaluation of devices and situations already largely *a priory* defined for her. By keeping the representation of the artifact and of the event undefined, my purpose was to invite the observer to actively complete my narrative, opening up my work to a multiplicity of interpretations and possibilities rather than narrowing them down.

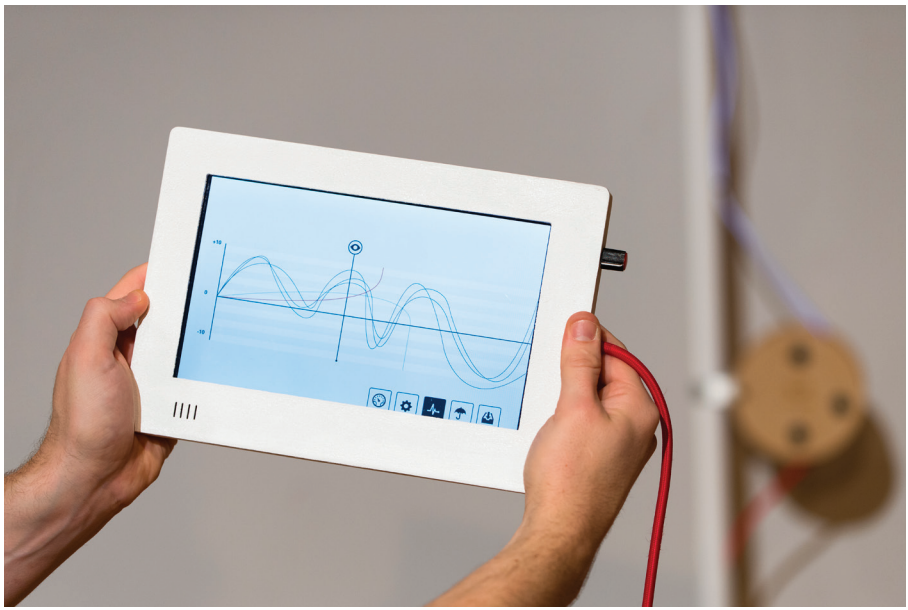
Speculative hacking

The purpose of Antenna was to explore how previously successful tactics for making industrial infrastructures present as material for design and participation might transfer from one domain into another. Inquiring into the structural properties of logistic infrastructures from a bottom-up perspective of course exposes certain aspects of existing structures and processes, but from an integrity point of view these do not need to be made very specific and connected to specific people or companies to be useful. Hacking mobile communications is a different matter, which leads us to key ethical dilemmas of experimental design in this area. To create a kind of material for dialogue similar to what was produced in previous experiments, the Antenna project makes use of similar tactics — a device to hack a system — but with an important difference: it is entirely fictional, not functional and the data it displays is imaginary. So we may ask: will it actually produce similar outcomes, or does the fictional character of the prototype make it less useful? And is this transition from 'real' to 'speculative' hacking a feasible and relevant design move or not?

Let us start by considering a negative answer to the question: saying that the difference between a functional and a non-functional prototype is crucial when it comes to unpacking the interactions and implications of a given design. While the Antenna differs from, say, fictional literature in that it is materialized in a different way it does not quite have the potential of design materials and hacking interventions that are 'real'. Now, if this is what we think, we face one of two scenarios. The first one implies that these hacks need to be 'real' to create the material outcomes necessary to move on. In the case of information and communication infrastructures, this is likely to imply legal issues, not to mention serious risks of privacy invasion. Thus, to continue and develop a 'real' version of the Antenna would most likely not be within existing national legal frameworks.

Alternatively, we may conclude that since prototypes must be functional at some stage to really work as prototypes, one should not produce or use any kind of thing not allowed within the legal framework or which might imply risks for





Data content and bandwidth use displayed
on the antenna interface.


Esplanaden
7B

the collectivity. The difficulty with this view is that we then end up in a position where we seemingly conclude that there are certain technologies, some of which we already live with, that we cannot experiment with and prototype: since it takes a functional prototype to unpack their interactions and agency, and as a functional prototype is not possible, a meaningful prototype is therefore not possible. Like the first scenario, this also leads to a problematic conclusion. Although there are certainly malicious technologies and applications we definitely should not prototype with, it is perhaps not entirely obvious that telecommunications fall into that category — especially since we already live with them and since companies and agencies with the right to access it already use this information extensively and outside the reach of public scrutiny.

It seems that both scenarios following a complete rejection of 'speculative hacking' are problematic in one or several ways. This why experiments as Antenna are interesting. By bringing ethics and aesthetics, practices and infrastructures, together they reveal issues related to how we develop new designs in contemporary industrial design practice. Whether by explicit intent or implicit habit, we typically use a design process through which both fidelity and functionality continuously improves as the process unfolds. While early explorative prototypes might not be functional and intended as means to investigate a design space, they are in most cases intended as part of a process that leads to functional objects or a device, where different iterations will progressively include final functionalities.

Here, however, we can already see from the start that the design process in question must not arrive at a fully functional object; the purpose of the Antenna prototype is fact not the definition of a device but to question possible systemic configurations and consequences behind certain actions. At the same time we know from experience that the closer to the 'real' thing, a fully functional prototypes, we get, the more we can — potentially — learn about what the thing really is. And so how do we know when it is a good idea to stop prototyping or questioning possibilities? How close to the real should we try to get in order understand the agency of our designs? Do we need to wait for something to necessarily happen or brake-down before considering re-design? These are not questions unique to this experiment, but issues that require more general attention. Ranging from questions of what to design – what to prioritize – in a world of finite resources; to what new technologies to unleash into the world through designs only presenting their advantages —their side-effects to be seen only later— the question of design realization quickly become less trivial than we used to think it was.

Previous page: photo in the studio. The hacker in his faraday poncho accesses data at the base of a large broadband antenna.

Right and above: photo on site
The contrast between the fictional appearance of this character and the reality of the background leave space for ambivalent interpretations. While taking the pictures for instance, we were suspiciously asked several times by people passing by if we were technicians or role-game players.

Left: what if local telecoms would provide an open API to develop locally based services upon the data content and capacity of their broadband antennas? As a way to address this question we installed a display monitor and public access point on the small cabin at the base of the antenna.

Next page: the hacker inspects the activity of a possible internet cables' junction box hidden in the woods.


BGH

Reflections on the antenna

While design moves such as 'speculative hacking' do not resolve these basic dilemmas, it opens up for revisiting the question of to what extent fictional design material can be considered effective in comparison to 'real' design materials. Indeed, it is not the Antenna as an end in itself that is most relevant, but rather its role in a design process still unfolding; its eventual usefulness to be determined through its role and influence in the process. Yet, as any design object, functional or fictional, it needs to be (re-)viewed also on its own: its 'consumption' might be restricted to just being material in this process, but it might also travel into new contexts, performing other functions, sometimes perhaps even becoming part of other agendas. Keeping such unpredictable futures in mind, we need a discussion about the nature of prototyping in areas where invisible things need to be made visible, but where sensitive matters must not be exposed at a cost we did not anticipate. As information technologies find ways into in our everyday lives, benefits and exciting potentials are not the only things to increase. The spreading of such technologies also carries with it new forms of design violence, problematic implications that we somehow also need to try to articulate in advance and not just mitigate in retrospective regret (Dilnot 2015).

Antenna and its fictional design will probably not provide the same use qualities of opening up for mastering and repurpose a system for 'real', as it happened with the trojanboxes. Nevertheless, it perhaps still maintains some important features typical of such practices. The portraits and their narratives still allow to speculate about future uses of the infrastructures and information it contains; to reflect upon its nature, agency and functionalities and to imagine what alternative practices that this kind of data gathering could support. This potential to support creativity is not only important in relation to future staging of participatory design interventions, engaging publics through this materials. But it might also bring something important to discussions about technological future-making as it allows, if only for a brief moment, to use our imagination to subvert and repurpose infrastructures and power relations that otherwise would remain untouchable to most of us.

As a prototype, a speculative materialization as Antenna, still allow designers to question and explore a design space (cf. Lim, Stolterman and Tenenberg 2008), articulating opportunities responses and actions that practices like mobile cell towers hacking might trigger, but without actually causing any potential harm. By

fictionally 'braking down the infrastructure', Antenna makes it suddenly present (cf. Bowker & Star 2000), relatable and questionable, opening it up to all possible interpretations about the damaging and positive implications and consequence that such an occurrence might entail for both citizens and network operators. It does so, not by providing a defined alternative or a statement about what a possible future might hide—representation that would inevitably induce a dialectic evaluation of acceptance or refusal of what 'that' is— but by providing open speculative scenario that still need to be fully explored and defined. Openness and diversity that are now necessary to be able to properly articulate postindustrial controversies, exposing the possible set of actions and counteractions that certain design decisions might trigger.

DISCUSSION

The design explorations presented in this thesis are the very first results of an experimental research program exploring what design practices and processes could be developed to support the transition of existing industrial infrastructures towards more citizen-centered and locally adaptive forms—what I call 'tran-structures'. As such, their purpose was to make early sketches and prototypes not of specific tools or technical solutions, but of new design and use practices, necessary to render these systems receptive and supportive to bottom up innovation and distributed form of production.

Indeed, bottom-up interventions as the trojanboxes, the drone-postbox and the Antenna presented are, in many ways, limited in their qualities and ability to concretely induce change within existing infrastructures. These case studies represent only a limited number of possibilities about how design could be used in relation to infrastructures, their exploration and transformation. Moreover, considering their final reach and results, they inevitably appear 'a bit pathetic' compared to the subversive intentions and ideals of democratization that inspire them in first place. Differences in access to knowledge and resources, time and personal designs skills, could have made more effective studies and extensive iterations of the same projects possible. Further, experimenting with different types of aesthetics and representations would have produced richer insights and broader perspectives on this process and its practices.

Clearly I cannot claim to have any final solution or fixed recipe for how to deal with industrial infrastructures and their transformation. The daunting task of redesigning infrastructures will involve a significant range of skills, professions and areas of expertise extending far beyond the reach of the (industrial) design discipline. Nevertheless, I believe experiments such as these show that there are significant opportunities for design when it comes to ways of knowing and designing with the infra-structural—that which is usually hidden beneath the surface— materializing and expressing it as a mean to collectively rethink its forms and functions.

In this dissertation, I have addressed the need for design not only to critically evolve its own discipline but also to initiate and curate change within the systems of industrial infrastructures and practices within which it operates and that currently limits the scope and reach of its innovations. Drawing from literature, I first offered an account of some of the strategic limits that prevalent bottom-up approaches to the design of systems and infrastructures have in addressing postindustrial needs and enabling a paradigm shift. Using this knowledge as

a backdrop, I therefore introduced the idea of a new type of postindustrial infrastructure — transtructures— to address postindustrial issues by means of providing more inclusive and accessible configurations. To empirically explore how this 'vision' could be realized, a possible programmatic research framework aimed at engaging publics with infrastructural issues was then outlined and rehearsed through the set of design explorations.

The starting point of this inquiry was that the symbiotic relationship between industrial and the postindustrial ways of production and consumption require the definition of a new design practice, which is able to transcend current dichotomies and development models (Fry 2009; Thackara 2006). If we want to learn how to possibly address such industrial and postindustrial problems, identifying opportunities outside the current industrial regime of development, with new multidisciplinary open and systemic approaches are needed. At the same time, methods that allow designers and researchers to inquire into the artificial space of infrastructures and to explore possibilities for their re-configuration need to be researched and experimented (cf. Dilnot 2015).

The result of these design explorations is an early prototype of a redirective and transitional practice for the design of postindustrial infrastructures. The design experiments outline the possibility of an alternative approach to the design and modeling of systems and infrastructures that is open for questioning and participation, but where the designer still maintains certain independence and authority in definition and proposal of what is ought to be designed. In what follows, I will discuss some of the qualities of these methods through a set of 'themes' that emerge as I now look back on the design interventions. Methodological, ethical and political implications of the use of participatory hacking practices, speculative and field performances in relation theory and design knowledge will be here presented. In particular, I will here address the relevance and possible contribution of these 'transtructuring methods' to the evolution of participatory design practices and the design of interactive and automated systems.

Themes

Sometimes actions at the verge of existing norms and rules are necessary to identify possibilities for innovation. It is, after all, difficult to "think outside the box" by limiting our search within its boundaries. The three case studies presented here provide examples of possible tactics and means to investigate the agencies

and mediations of present infrastructures and future configurations by making their 'figure' present and available for conversation and judgment. Through these actions possible conflicts, possibilities and consequences of their agency were exposed. Working as Latour's 'plug-ins', probes and speculative materials altered and undermined the apparent stability of their design space, challenging the physical, technical boundaries of its underlying infrastructures, its social habits and design conventions (cf. Latour 2005, 209).

Similarly to what happens when throwing a stone in a pond causing ripples to expand on the water surface, these design activities destabilized the design space making its actors and agencies observable and relatable counteracting naturalizations and conservative tendencies towards stability (cf. Bowker & Star 2000; cf. Dewey 1954). The participatory hacking session with the trojanboxes offered participants and myself a tool to re-animate the material and logics behind the design of infrastructures that with their structures and logics defined that space and situation. The drone-postbox exposed the inhabitants of Floda to the design of an alternative systems, allowing them to interface with something very different from their previous experiences of infrastructures and to which they would have hardly be able to relate otherwise. Finally, Antenna allowed discussing the possibility of a potentially harmful event such as hacking mobile broadband networks through its speculative mockups and portraits.

These 'destabilizing actions' are necessary to access and expose the 'figure' of existing infrastructures and explore opportunities for their reconfigurations (Suchman 2012), by providing the means to relate and unfold relations between their human and non-human actors at local and global scale (Latour 2005, 174-213; Latour 1996). Besides making the agency of present and future configurations available for judgment, what participatory hacking and speculative designs practices share in common is that they are both 'adversarial' (cf. DiSalvo 2012). They both express criticism toward existing organizations and governance mechanisms of infrastructures, through objects, visual materials and events that expose limits and propose alternatives to their current forms. Below, I will discuss these transtructuring practices through a set of themes — *Civic Hacking; Speculative Futures and Disruptive Events; Presence; Postindustrial Archetypes* and *'A Third Way'* — as the means to better articulate some of their qualities and meanings in relation to the program and its original intentions.

Civic hacking

Hacking as a mean to cleverly explore ways to bypass the obstacles of existing restrictions is perhaps the most familiar form of adversarial practice. Although it might feel distant from the reality of our daily life, news about hacker attacks to infrastructures and databases by activists groups or intelligence organizations have become quite common in the media. Clearly the way the trojanboxes were employed with people in Floda did not share the same disruptive intentions. This particular use of sensor probes to access infrastructures was more oriented to knowledge production and experimenting with ways to engage publics in the explorations of mundane infrastructures such as logistic systems (cf. Dewey 1954). However, by making the functionalities and operation of these networks present and available for public scrutiny, they still do agonism.

To allow the exploration of multiple networks at the same time and identify possibilities for change, protocols and rules that define uses and interactions of private (rather than public) logistic services had to be broken. Thus, the trojanboxes do represent a form of adversarial design in the way they playfully and subtly allowed members of the community of Floda to 'contest' the way existing global logistic companies exclude them from an equal right to access to infrastructures. This apparently innocent form of protest still maintains a strong political and symbolical connotation since it expose companies to the potential risks associated with these practices. Turning the trojanboxes from being about playing and learning to be about cracking or taking advantage of system weaknesses is after all not so difficult to imagine.

It is also because of this ambiguity that participatory hacking practices as a form of civic engagement seems to have the power to provide the necessary dialogical material to rebalance power relations between citizens and corporations. On one hand they expose possibilities for change and innovation, on the other they show companies what could be the consequences of not meeting citizens' needs. In today's global, liberalized and deregulated market, decisions about infrastructures and their operations often take place in facilities and headquarters located in different regions and countries according to internal criteria of control and efficiency that might not meet specific local demands. Front-end personnel merely execute decisions from above. These features not only make these networks hard to relate to, but they also make it difficult to coordinate and adjust their activities to local needs.

Participatory hacking through sensors probes could be therefore considered a kind of 'activist design game' that citizens could use to enforce a discussion about local issues that in many cases is not possible anymore. An agonistic and participatory tool for democratizing innovation moved by the same desire to democratize decision making that interested designers such as Pelle Ehn in the 80s for exploring means to facilitate this process, but simply in a different in a different historical context. As Björgvinsson, Ehn and Hillgren (2010) notice "it may be argued that an 'agonistic' perspective on 'democratizing innovation' is just a continuation of early approaches to participatory design", and that the "agonistic" view on democracy is very much in line with the early Scandinavian model of participatory design and struggles for "democracy at work" (Bjerknes, Ehn and Kyng 1987; Ehn 1988).

As it emerges from the experience of making and using the trojanboxes there seems to be several possibilities for design in crafting re-directional, antagonistic design probes for civic purpose, as a mean to foster the process of democratization of infrastructures. By revealing the functionalities and systemic agencies of existing systems — currently defined by criteria of control and technical efficiency only— they become available for a different range of interpretations, allowing a contamination — or a "transvaluation of values" (Nietzsche 1976) — between what is inside and what is outside them. This provided participants and designers with the means to evaluate their qualities and understand how to possibly reframe their interactions locally, materializing qualitatively different —more inclusive and locally responsive—future alternatives. I would therefore argue that participatory hacking tools like the trojanboxes represent an example of a possible instrument and process of inquiry that designers could craft and use for eliciting and supporting participatory approaches of adversarial design (DiSalvo 2012).

Speculative futures and disruptive events

Considering their dual nature — constructive or destructive— hacking practices might raise several ethical questions about the responsibility of the designer to avoid damaging and negative consequences of her practices. The experimentation with speculative hacking forms such as Antenna provide an example to address these issue and elude some of the risks and responsibilities normally associated with this type of action. If infrastructures become visible only after they break down, the Antenna project offered an example of a way in which

design means can be used to simulate a disrupting event, avoiding the legal and ethical implications that a real hack would have entailed.

Through the materialization of a possible device to intrude into the broadband networks, Antenna provided the means to relate to and reflect upon the agency and politics of this infrastructure, its meta-data markets dynamics and the possible consequences of such action. By opening it up for questioning and interpretations, it allowed us to articulate issues around the security of systems in face of its intrinsic hackability of technologies. Because of this ability to reveal the disposition of present practices and the limits that current standards invisibly exert on the scope of designers actions, speculative designs such as Antenna critically address the authority of existing broadband infrastructures. As such it does represent a form of adversarial practice too (cf. DiSalvo 2012; cf. Edwards 2003; cf. Easterling 2014).

Indeed, the use of design forms as an expression of critique and speculation about alternative infrastructural configurations is not new. As illustrated in the background section of this dissertation, design has been operating in the realm of the critical and the speculative for a long time. For instance, the radical futures proposed by studios such as Archigram and Superstudio in the 1970's; Stewart Brandt's Whole Earth Catalogue and the work conducted by Negroponte and others at the MIT's Architecture Machine Group are all in a way examples of speculative and critical design forms in the realm of the infrastructural. Similarly, more recent work in the field of sustainable scenarios and service systems anticipates many of the possibilities for efficiency and sustainability that business models based on the shared used of materials and resources enabled by information technologies (cf. Jegou and Ezio Manzini, 2008).

In these kinds of design practices, we can clearly see that 'practice' does not only conform to market but can anticipate it. The scenario and materialization of an alternative future like the one offered by the drone-postbox relate in many ways to this body of work, where speculative representations of future infrastructures are used to envision proximate solutions to emerging social needs. By offering an alternative design of a delivery system, it exposes the limits of the current situation allowing people and designers to critically question the design decisions of the past that led to present configurations and to discuss the kind of future they want (Dunne and Raby 2013; Lukens 2013). Nevertheless it also differs from them in the way this concept is both result-of and a tool-for participatory design activities and interactions in the field.

Presence

To a significant extent, design speculation happened within its own formats, in exhibitions and media rather than in the field. When dealing with large systemic and contradictory societal and technological issues, however, presence and participation seem to be strategically important to allow a common understanding of an issue and a more inclusive assessment of a future design and its mediations. Through the staging and rehearsal of the drone delivery system, speculative design materials were used and adopted into a participatory process. This offered the local inhabitants of Floda the means to interact for a brief moment with this future possibility and to collectively imagine and anticipate its uses and mediations (cf. Verbeek 2011).

Although this might sounds similar to what happens within other participatory practices (cf. Ehn 1988), this way of working and prototyping with socio-technical material in the field is, epistemologically, quite different from, for instance, experimenting and evaluate prototypes in the lab or experiencing speculative designs in a museum or through a book. By providing an 'experience' of this alternative configuration— bringing a future system as close and present as possible to real life conditions — future users could thoroughly perceive and judge the qualities and motivations that guided its design. Braking up their habits —'suspending their disbelief'—they could actively engage in a discussion about the practices this possible future drone delivery system could support providing designers with the necessary information to properly attune its design to its future context of use (cf. Dewey 1987).

This process of knowledge production is not univocal. Through the rehearsal of speculative system design in the field, designers can engage publics in a discussion about their envisioned systems, opening up their design to a diversity of interpretations and contextual factors. In this way, another process of 'transvaluation' is enabled, by exposing their plans and projects to those who will be affected by it, they make their practice questionable and interpretable, allowing a richer and compressive understanding of the different meanings a single system can have (cf. Tracy 1994). Feelings and mutual agencies — Merlau Ponty's phenomenological description of 'feeling and been felt' mentioned in the methodology section of this dissertation— that otherwise would be inevitably missed in the evaluation of future designs are brought in (Merleau-Ponty 1968). Through this type of relational understanding of the dynamics established by the possible interaction between the inhabitants of Floda, their contexts and the

new infrastructure, possible criticalities of this concept and its future mediations could emerge.

The idea of a network operated by unmanned vehicles has indeed several limitations. Drones might not best the fitting option for this purpose in the landscape of Floda and represent only one of the many possibilities available and that could have been experimented. However the process presented here is not about problem solving or evaluation of this specific design concept. Rather, it is about 'questioning and exploring' what conversations emerge when something that is otherwise invisible is made tangible and present in a context through prototypes, in the early stage of the design process, when focus lies on opening and becoming.

Therefore, the value of the drone-postbox project is not in the solution it provides per se, but in 'how' it was conceived and what it expressed through its rehearsal in the field. That is, the set of design explorations that first, allowed to re-animate and question the figure of the existing infrastructures that shaped the design space—providing the necessary knowledge and materials to think about alternative configurations— and the staging and rehearsal of one of these possible solutions, opening up the design of this future concept to the world as a way of knowing and attuning its impact and presence within it. Certainly, these revealing and materializing tools and activities could be employed independently, as the means to generate material for design and explore future configurations. However, it is through their combination that they seem to provide the necessary insights and argument to provide disruptive innovations —divergent from industrial development criteria— with the necessary foundations for their development.

Postindustrial archetypes

There are also things to be said about the particular kind of aesthetics experimented with in the design of drone-postbox and Antenna and the pictorial material produced to introduce their concepts. These speculative designs and early prototypes are both tools to explore and investigate a specific design space as much as they are an outcome and a possible solution to it. As such they embed more than the tacit knowledge necessary to produce them. This 'more' is the ability of these artistic expressions to impart and evoke fundamental ideas and perspectives that disclose the world for us and, at the same time, render that

world into what it is or can be. Their purpose is both perspectivist and performative: by offering a experience they provides outlooks and insights that bear on our relationship to the world and to other people as well as our perspective on what it is or should be (Borgdorff 2011).

These materializations intentionally escape industrial product aesthetics often used also in design research, offering as an alternative a set of unrealistic yet possible devices and systems configurations whose form and functions are suggested but not defined. By playing between the familiar and the unfamiliar, the real and the fantastic, these prototypes and their basic shape are intended to leave space to the observer to imagine and interpret what these things are, what they represent and what they could become (c.f. Sengers and Gaver 2006; cf. Tonkinwise 2011). They are open canvases, functional to the definition new structures, forms and uses that cannot be expressed before exploration because they never existed before (cf. Redström 2008). As such they represent primitive and archetypal figures open for imagination and interpretation, necessary to express, explore and develop a new postindustrial design code and language, diverging from today's industrial aesthetic homologation (cf. Branzi 1988).

These artifacts and prototypes proved to be useful in their ability to explore and filter information about the design space (cf. Lim, Stolterman and Tenenberg 2008), allowing to speculate and to anticipate some of the possible practices and behaviors their styles and configurations could enable and those they could limit (cf. Tonkinwise 2011). However, it is also possible to highlight some limits, particularly in regards of the politics of the imagery produced and its still, in a way positive representation of technology. For instance, images of the drones flying above forests finally landing in its cute little house still convey a quite positive feeling that might be quite different from visualizing and presenting flocks of drones flying in the sky. With the Antenna a step towards more neutral images was attempted, although different type of representations could have been produced to expose publics not only to the possibilities of hacking data but also on other issues and consequences of meta-data use. A more compressive exploration articulation of these concepts and events would therefore require a more extensive exploration of different types of styles, aesthetics, materials and visualizations in order to open up for different kind of interpretations, feedback and level of insights.

A third way

The sequential use of a participatory hacking and speculative design performances in the field offer a glimpse of what the possible constituent activities of a 'transtructuring practice' can be: a material inquiry and a design process where designers engage in strategies of figuration in order to explore how to give new meanings and forms to ecologies of actors and networks already in place[18]. In particular they provide an example of a possible approach to the modeling of systems and infrastructures that transcend the dialectical opposition and controversies between top-down and bottom-up, pointing toward a new direction. The designer's work does not here align to the needs of a particular client or community, but becomes the means to mediate between a diversity of interests, exploring and articulating ways, through her practice, to meet their conflicting needs.

The first step of this practice and its framework require designers to identify ways to re-animate the figures of the underlying infrastructures that shape the design space. This entails the development of actions and tools to materialize and critically expose dispositions and limits of existing infrastructural arrangements. Once materialized this knowledge can be used within participatory processes as dialogical materials to engage public in a discussion about how these could be possibly changed towards more citizen centered configurations. Different synergies between existing industrial networks and their interactions at local level can be then collaboratively explored, identifying strategies to properly attune new systems to local needs and to avoid replicating unsustainable patterns of development (cf. Fry 2009). Designers can then conceptualize these ideas into possible economically, environmentally and socially viable concepts. These concepts can be then open up to citizens, through forms of public performances, using mockups to stage and rehearse possible future infrastructures in the field. By making the agency of future systems experienceable and available for discussion and feedback designers can finally investigate the mediations of these new configurations in their context of use.

What emerged from this description is that this process is neither entirely top-down nor bottom-up, but different degrees of openness, criticism and participation co-exist within it. During the course of these design explorations — and in

18 In 'Participation in Design Things' Pelle Ehn (2008) provides a description of 'reverse infrastructuring', which might share several similarities and qualities with this definition.

particular the more extensive process that led to design of the drone-postbox—no *a priori* brief, function, practice or target group was set before the experiments. Ideas and information about how to possibly transform the existing industrial infrastructures toward more locally adaptive forms were generated in the process and interaction with the site and it actors. Knowledge about the context was produced from the ground-up, allowing me to interpret agencies to investigate possibilities for their reconfigurations without necessarily having a task or a client in first place.

The critical and speculative materials used to reveal infrastructures and stage future system configurations provided participants with the means to interpret today's socio-technical transformations, making phenomena otherwise complex and difficult to grasp, relatable and context-specific (cf. Graham and Marvin 2001, 8-9; cf. Sassen 2014 7-11). Provoked by these materials and performances, actors and networks 'self defined' themselves through their presence, materialities, dialogues and interactions (c.f. Latour 2005, 43-86). Participants spontaneously engaged in these explorations allowing with their anecdotes and accounts, to unfold several of the different agencies, practices, and power relations that characterize the design space. Through this dialogue with the material and the situation the designer can interpret contextual issues, elaborating plans, actions and dialogues necessary to enable a transition towards preferable configurations and mediate between the conflicting needs of industry and citizens.

In this transtructuring process, the designer is still responsible and autonomous in her decisions and interpretations of what can be 'necessary' and 'preferable'. As for the actors in Brecht's Chinese theater however, this role also becomes triggering questions in its audience, disclosing, through a performative dialogue with the material, the 'mystery' of the infrastructural space and the proximity of possible future alternatives. By opening up the design process for question and interpretation, the designer invites participant and other stakeholders to become the 'estranged' observer of her actions and participate to definition of future solutions (cf. Brecht 1964). This mode of acting 'in and onto the material world' embeds the political and ethical values of the designer but opens them to others for questioning and feedback. As Dilnot suggests, this is an ethical way of acting that "is subjective but it does not stay in the subjective" and that "brings the poises actively into ethical and political relations and makes it possible to see our thinking/acting in these terms" (Dilnot 2015, 198).

The political value of transtructures

It could be rightly argued that transtructures represent one specific model of development and defined design direction, from which research for presently excluded future possibilities and other forms of configuration should be explored. For instance, the design of the drone-postbox explicitly express a solution aimed at counteracting the effects of centralization and automation on labor in specific geographical areas and financial hubs (cf. Easterling 2014; Fuchs 2010; Qiu Gregg and Kate Crawford 2014). Alternatively one could explore solutions aimed at facilitating these processes, supporting established means of governance and application of technology and solving the several problems that might emerge as a consequence of these dynamics.

These two views express the difference between political design and design for politics. Indeed, practices of design for politics are necessary and perform an important task. However, transtructures have a political meaning because they are openly and intentionally redirective. They antagonize the idea of design as a discipline that a-critically conforms to existing industrial patterns of production; their tendency to centralized control of assets and resources (Winner 1989) and their unsustainable expansion models responsible for inequities and injustice on both local and global scale (Fry 2009; Margolin 2002). These outdated development strategies, appear unable to produce for the common good anymore and confine design to a continuous patching activity of problem-solving flaws and mistakes that unethical backward looking modes of development and applying technologies keep reproducing (Dilnot 2015).

In opposition to these kind of 'defutured futures', the exploration and prototyping of practices and processed for the design of transtructures, is a way to reaffirm the embodied and situated nature of design, and the relevance of the intentional configurative role of designers in the identification of qualitatively preferable solutions. By giving form to a political condition, design moves beyond rising awareness and critique; it can "produce a shift towards action that model alternative presents and possible futures in material and experimental form. This provides the foundations for examining and reconstructing the political conditions as they are and also for imagining the political conditions that might be" (DiSalvo 2012, 118-119).

Concluding remarks

The term 'transtructures' has been here used to sketch a new type of infrastructure supportive to distributed manufacturing and service economies. The articulation of this concept is the first contribution of this thesis as it provides the speculative model of a new type of socio-technical configuration, through which to possibly address postindustrial tensions and controversies. This notion offered the starting point for a set design explorations investigating what kind of practices would be necessary to achieve this vision. The result of this inquiry is the early prototype of a re-directional and transitional practice for the design of postindustrial infrastructures. The definition of this approach to the design and modeling of new socio-technical systems represents the second contribution of this thesis: A 'transtructuring' process where materials and forms are used as the means to question and inquire into existing infrastructural arrangements and explore opportunities for their reconfiguration and transition towards more contextually adaptive forms and functions.

Due to its critical attitude towards the disposition of existing industrial practices and configurations this work might appear purely speculative and perhaps not interesting from a managerial and administrative perspective. Indeed, new system designs such as the one suggested by the drone-postbox project are in many ways radically different from incremental and internal innovation processes industrial companies are used to. Nevertheless, in a context where technical analysis and social decryptions are not able to provide any guidance about future directions this kind of design explorations might provide an important contribution.

When it comes to deciding about conflicting and complex problems such as sustainability or assessing the social impact of new design configurations, there is no right or wrong solution, but options with consequences. By learning how to articulate and anticipate them, companies and public administrations can gain more insights into how to plan and manage their transitions towards postindustrial configurations. Indeed no one has the ability to predict the future and to prescribe action accordingly. Moreover it is perhaps premature to evaluate its possible achievements. The outcomes of these first experiments however, suggests an ability of this transtructuring process to provide a possible tool to guide the decision making process and lead to the definition of new citizen-centered infrastructures and services (cf. Towsend 2013).

When the systemic agency of networks and technologies represent a matter of public concern and a source of discrimination and controversies, single actors initiatives are insufficient to provide solutions. But multidisciplinary approaches that are open to a diversity of interpretations are necessary to identify what could be 'preferable' ones. By prototyping them, and opening up the design process to people and publics, companies and public institutions could collaboratively explore how to achieve preferable scenarios and reconfigure their systems and interactions accordingly. This is probably not going to be like exactly predicting the future but at least it could be a way to 'feel around the corner', anticipating systemic risks and consequences associated to certain solutions instead of others.

A development strategy

The concept of transtructures was initially conceived to provide a possible direction in which to explore a new type of infrastructure more sensitive to local needs and supportive to local economies. The intention behind this concept was to counteract the exclusion and marginalization that characterize current markets infrastructural development (Sassen 2014), offering as an alternative a model where knowledge and value produced by infrastructural assets remains within the communities that use them (cf. Olivetti 1946). Through a more equal access to infrastructures and technological assets, ideally, more sustainable market and economies could be raised, fostering inclusion and social progress.

This vision and ideas has been then investigated through a series of design experiments aimed at prototyping a possible 'transtructuring practice', not focused on provision of end-results on the base of 'knowing that' descriptions and explanations; but on 'knowing how' to identify, qualitatively evaluate and achieve these configurations. What seems to emerge from these explorations is the existence of a possible leading role for design as means to identify strategies and guide the development and implementation of distributed model production and economies (cf. Biggs, Ryan, & Wiseman 2010; cf. Johansson, Kisch and Mirata 2005).

As a regional development strategy, transtructures has the potential to support the de-centralization of production and manufacturing activities from the saturated space of cities, rebalancing the relation between production and land (cf. Berg and Rydén. 2012): In the short term, by providing the necessary facilities and services to make otherwise emptying urban settlement attractive to people

and small-scale entrepreneurial initiatives by reconnecting them globally; In the long term, by proving large manufacturers with the necessary infrastructures to shift their business models from selling products to enabling access to automation, service and manufacturing platforms. In a distributed manufacturing scenario in fact, only certain parts and components will be scale manufactured by companies while products' final designs will be largely defined and produced locally by customers and micro-factory retailers. Material and information flows and infrastructures able to respond to local needs are necessary for the sustainment of such systems and to enable new types of supply chains and local global relationships.

In this context, transtructures offer public and private actors a possible model through which to explore alternative configurations and more democratic uses of technology. In particular, they provide an example of what practices and processes might be necessary to explore contexts and to collaboratively identify possibilities to redefine interactions across networks of systems and infrastructures. By 'transtructuring' they could collaboratively identify how to better serve local economies and communities and attune existing infrastructures toward these locally adaptive configurations, acknowledging what changes this would require on their behalf to support these new systems.

Design postindustrial systems

Distributed and artificial intelligence indeed embeds a great flexibility for different types of applications and potential for liberation. At the same time though, it conceals great risks and possibilities to reinforce social conflicts and inequities or give shape to new forms of violence that we must, as designers, learn to anticipate, by taking responsibility for our actions. This is to say technology per se does not own a morality, but is the role of designers to give it one (Verbeek 2006; Latour 1992; Winner 1989). The increasing complexity, ubiquity and infrastructural nature of IT and automated systems require designers to explore new ways to responsibly and properly introduce them.

As illustrated in the background section, products, devices and IT applications can always be designed and introduced incrementally as mean to supply commodities, in an old industrial fashion, as an extension at the front end of infrastructures and their networks. However, case studies such as the Satin project (p.84) provide evidence of how usability and user centeredness are in

many cases not sufficient to inform how to give a possible design solution the contextual sensitivity required to meaningfully give them a place in people's life. Awareness about these limits and role of technological mediation and its politics is particularly relevant for the development of the design practice.

The design processes explored in dissertation represent a step in this direction. In particular it offer an example of a possible framework to question and investigate dispositions and agencies of present and future infrastructural configurations and a 'use trough use process' (Redström 2008) that can be used to inform the design and modeling of new socio-technical configurations. Situations where acknowledging and anticipated agencies, mediations and systemic interactions of the different actors and networks that define a design spaces is necessary to provide the new design and its arrangement with the proper foundations to be meaningful.

In this transtructuring practice, designers open up their ideas and skills to the outside world, bringing design and prototyping from the studio 'into the streets', engaging people in a collaborative process of understanding how these designs might travel and be appropriated in different contexts (cf. Verbeek 2006). By giving a presence to existing networks, opening them up for participation it became possible to first explore how to re-configure and adapt them to local needs. Then, through the staging and rehearsal of a future system in the field, agencies and mediations of these futures configuration become observable and questionable, allowing designers to properly adapt their design to the context of use. This is not the only outcome of this field rehearsal though.

Through the staging of the drone-postbox for instance, it became possible to start discriminating what elements and components of the new distributed networks could be scalable and replicable and which once could be customized and left in control of local communities (p.198). Insights that offer an interesting perspective on how to design in a context where products and content are open and customizable. In the age of digital and distributed manufacturing, understanding how the 'code' —the general script behind the provision of new product and services— will be appropriated and replicated in different places and different people is fundamental to understand what these products and services will be (cf. Ehn 2008; cf. Hunt 2005). Through this open and extended prototyping process, this 'essence' and DNA —the immutable element of always different and context adaptive products and service— of what constitute these new enabling platform can be identified.

Future research directions

The practices and framework researched and discussed in this dissertation are still in an explorative stage and located within a very limited number of infrastructures. Thus, it would be premature to generalize its findings or evaluate their quality. However the positive outcomes produced, and the several features and issues that different types of industrial infrastructures and forms of organization share —such as their naturalization, divide and last mile problems— offer a reasonable basis to think that this approach could provide interesting results within other contexts and networks.

Indeed further explorations are needed to better understand the limits of this framework, critical aspects it might hinder and practices it could include. There is still a broad gap between the elusive descriptions of what transtructures are and the need to explore design practices and directions to configure them on the other. The presence of this tension however and the initial results provided by these first explorations of what 'transtructuring' means and could be, open up several opportunities for development and allow me to outline some possible future research directions:

- **Industrial Partners:** Companies' internal knowledge, resources and expertise are necessary to achieve the balance and symbiotic relationship between their networks and bottom-up innovations that this redirective practice aims for. The design experiments presented in this thesis could definitely have been initiated from the bottom up as a way to start a dialogue and expose possibilities for change when no other possibility to access information is available. Beside the knowledge and insights that such intervention can produce however, it is only through the collaboration with industrial partners and public institution that the ability of this approach to enable transition and curate innovation could be fully evaluated. Thus a further developments of this research will not only attempt to explore what type performances and materializations certain infrastructure might requires and allow for, but also to engage industrial and institutional partners in open up their networks and collaboratively explore new market configurations and interactions. As postscript note in this direction, after the drone-postbox project received some media attention, companies prompted by this study spontaneously engaged in conversations about the meaning of these explorations and their scope. Beside of opening up for new research opportunities, this interest could be

interpreted as a further proof of the ability of design materials and performances alone to engage and create the conditions to enact participation.

- **Artistic Practices:** The constructive approach employed in this research provided evidence of the ability of art-based research to articulate and unfold complex systemic issues, producing knowledge about future possibilities that would be otherwise difficult to address through other types of inquiry. Within this dissertation I engaged with practices such as public performances in the field and experimenting with different types of imagery and forms of expressions to open up the design process to a variety of people and stakeholders. These performative uses of materials and theatrical forms of public engagement are perhaps relatively new for design. Nevertheless they have been part of the artists' portfolio for a long time if we think, just to mention some, at performances like Allan Kaprow's 'happenings' or Augusto Boal's 'theater of the oppressed'. Further exploration of these practices and their knowledge could be therefore recommended to better understand what forms and expressions public design performances could include. This would perhaps help designers by increasing their competences and awareness when performing such events, giving them better tools to articulate insights and unfold the complexity of the outcomes they produce and convey them to other practitioners. At the same time further experimentation with different kind of support materials, media and aesthetics, is necessary to better understand what this transtructuring framework is and what other possibilities for tracing and materializing infrastructure are possible.

- **New Commodity:** A third theme that deserve further attention is finally the understanding of to what extend transtructures might represent a new form of commodity; the final evolution of the scope of design from product to service, to market and infrastructures. Through the processes of digitization, of automation, of production and service supply the distinction between infrastructures and interface vanished. With infrastructures moving towards the user level, understanding how their functionalities, products and services can travel and be appropriated in different context might represent a new purpose for design. Whether postindustrial design process —such the one outlined in this dissertation— aimed at discerning between scalable and customizable assets might lead to provision of a new kind of commodity, favorable to capitalists markets development, is indeed, still an open question and controversial point departure for future research and investigations.

Conclusion

In the context of today postindustrial economies, the development of approaches to responsibly guide companies and institutions in the exploration of infrastructural configurations more attentive and responsive to the needs of people and communities is fundamental to ensure sustainability and social progress. In this dissertation I began to explore what one such practices could be, through the articulation of a programmatic research framework for a redirective practice aimed at engaging publics with infrastructural issue. Through a series of design experiments in the areas of logistic and telecommunication I started to engage with the politics of infrastructures, exploring method and tactics to render these systems receptive and supportive to bottom-up innovation. These experiments offer an example of this research program and a possible approach to initiate and curate the transition of industrial infrastructures towards more open and locally adaptive configurations. In particular, they illustrates the rich potential and opportunities for design when it comes to ways of knowing and designing with the *infra*-structural—that which is usually concealed beneath the surface of human interactions. Because of their explorative nature, these experiments still have some limits and perhaps lack of the necessary depth and quality to fully understand what this programmatic framework 'is' and its possible reach. Clearly there are many possibilities, methods, political and legal issues and areas of application that still need to be explored and many open questions that still need to be addressed. But nevertheless they still provide evidence of an interesting space and field of application for design to inquire into the artificial space of infrastructures and collectively explore possibilities for their reconfiguration. As such, this dissertation should be seen more as a starting point rather than an end; an invitation to other designers and researchers to engage with and expand the scope and variety of this program, and eventually expose its limits.

References

Albers, Anni. 1968. *Oral History Interview with Anni Albers*, by Sevim Fesci. Archives of American Art, Smithsonian Institution. New Haven, Connecticut.

Arendt, Hannah. 2013. *The Human Condition*. Chicago: University of Chicago Press.

Baudrillard, Jean. 2010. *Pour une Critique De L'économie Politique Du Signe* [For a critique of the political economy of the sign]. Trans. Pierre Dalla Vigna. Milano: Mimesis.

Bell, Daniel. 1976. Welcome to the post-industrial society. *Physics Today* 29 (2): 46.

———. 1973. *The Coming of Post-Industrial Society: A Venture in Social Forecasting*. New York: Basic Books.

Berardi, Franco, Gary Genosko, Nicholas Thoburn, and Arianna Bove. 2011. *After the Future*. Edinburgh: AK Press.

Berg, Per G. and Lars Rydén. 2012. Urbanization and urban-rural cooperation. In *Rural Development and Land Use*. Vol. 3 of Ecosystems Health and Sustainable Agriculture. Uppsala: Baltic University Press.

Biggs, Che, Chris Ryan, and John Wiseman. 2010. *Distributed systems: A design model for sustainable and resilient infrastructure*. Melbourne: Victorian Eco-Innovation Lab/University of Melbourne

Bijker, Wiebe E. 1987. The Social Construction Of Bakelite: Toward a theory of invention. In *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*. Cambridge, MA: MIT Press, 2012.

Bijker, Wiebe E., Thomas P Hughes, Trevor Pinch, and Deborah G. Douglas. 2012. *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*. Cambridge, MA: MIT Press.

Binder, Thomas, Eva Brandt, Joachim Halse, Maria Foverskov, Sissel Olander, and Signe Yndigegn. 2011. Living the (co-design) lab. In *Proceedings of the Fourth Nordic Design Conference, Making Design Matter*. Helsinki.

Binder, Thomas and Johan Redström. 2006. Exemplary design research. In *Design Research Society Wonderground International Conference*. Lisbon, Portugal

Bjerknes, Gro, Pelle Ehn, and Morten Kyng. 1987. *Computers and Democracy, a Scandinavian Challenge*. Brookfield, VT: Gower Publishing.

Björgvinsson, Erling, Pelle Ehn, and Per-Anders Hillgren. 2010. Participatory design and democratizing innovation. In *Proceedings of the 11th Biennial Participatory Design Conference.*

Boehner, Kirsten, William Gaver, and Andy Boucher. 2012. Probes. In *Inventive Methods: The Happening of the Social*. Ed. Celia Lury and Nina Wakeford, 185-201. London: Routledge.

Borgdorff, Henk. 2011. The production of knowledge in artistic research. In *The Routledge Companion to Research in the Arts*. Ed. Mark Biggs and Karlsson Henrik, 44-63. London & New York: Routledge.

Borgmann, Albert. 1987. *Technology and the Character of Contemporary Life: A Philosophical Inquiry*. Chicago: University of Chicago Press.

Bowen, Simon. 2010. Critical theory and participatory design. *In Proceedings of the 28th ACM Conference on Human Factors in Computing Systems*. Atlanta, Georgia.

Bowers, John. 2012. The logic of annotated portfolios: Communicating the value of'research through design'. In *Proceedings of the Designing Interactive Systems Conference*. Newcastle, UK.

Bowker, Geoffrey C. 1993. How to be universal: Some cybernetic strategies, 1943-70. *Social Studies of Science* 23 (1): 107-127.

Bowker, Geoffrey C. and Susan Leigh Star. 2000. *Sorting Things Out: Classification and Its Consequences*. Cambridge, MA: The MIT Press.

Boyd, Danah and Kate Crawford. 2012. Critical Questions For Big Data. *Information, Communication & Society* 15 (5): 662-679.

Branzi, Andrea. 1984. *La Casa Calda: Esperienze del Nuovo Design Italiano*. Milano: Idea Books.

———. 1988. Those monks on the hill. In *Learning From Milan: Design and the Second Modernity*. Cambridge, MA: MIT Press.

Brecht, Bertolt. 1964. Alienation effect in chinese acting. In *Brecht on Theatre: The Development of An Aesthetic*. Ed. John Willett. Alienation Effect in Chinese Acting. New York: Hill and Wan.

Brown, Tim. 2008. Design thinking. *Harvard Business Review* 86 (6): 84.

Brunton, Finn and Helen Nissenbaum. 2011. Vernacular resistance to data collection and analysis: A political theory of obfuscation. *First Monday* 16 (5)doi:http://dx.doi.org/10.5210/fm.v16i5.3493.

Buchenau, Marion and Jane Fulton Suri. 2000. Experience prototyping. In *Proceedings of the 3rd Conference on Designing Interactive Systems: Processes, Practices, Methods, and Techniques*.

Burke, Jeffrey A, Deborah Estrin, Mark Hansen, Andrew Parker, Nithya Ramanathan, Sasank Reddy, and Mani B. Srivastava. 2006. Participatory sensing. *Center for Embedded Network Sensing*.

Burns, Colin, Hilary Cottam, Chris Vanstone, and Jennie Winhall. 2006. Red paper 02. Transformation design. Design Council.

Bødker, Susanne. 1996. Creating conditions for participation: Conflicts and resources in systems development. *Human-Computer Interaction* 11 (3): 215-236.

Carney, Michael. 2014. Angry LA residents are trying to sabotage waze data to stop side-street congestion. Accessed January 5, 2016. https://pando.com/2014/11/17/angry-la-residents-try-to-sabotage-waze-data-to-stop-side-street-congestion/

Ceschin, Fabrizio. 2013. *Sustainable Product-service Systems: Between Strategic Design and Transition Studies*. New York: Springer.

Chandler Jr, Alfred D. 1993. *The Visible Hand.* Cambridge, MA: Harvard University Press.

Chesbrough, Henry. 2010. *Open Services Innovation: rethinking your business to grow and compete in a new era.* Hoboken, NJ: John Wiley & Sons.

Chordia, Tarun, Amit Goyal, Bruce N. Lehmann, and Gideon Saar. 2013. High-frequency trading. *Journal of Financial Markets* 16 (4): 637-645.

Coleman, David C, David M Swift, and John E Mitchell. 2004. From the frontier to the biosphere: A brief history of the USIBP grasslands biome program and its impacts on scientific research in north America. *Rangelands* 26 (4): 8-15.

Crang, Mike and Stephen Graham. 2007. Sentient Cities, ambient intelligence and the politics of urban space. *Information, Communication & Society* 10 (6): 789-817.

Crawford, Kate. 2014. The anxieties of big data. *The New Inquiry*. Accessed Jan 4, 2016. http://thenewinquiry.com/essays/the-anxieties-of-big-data/

Cross, Nigel. 2001. Designerly ways of knowing: Design discipline versus design science. *Design Issues* 17 (3): 49-55.

Cuartielles, David. 2014. How deep is your love? On open-source hardware. In *Making Futures: Marginal Notes on Innovation, Design, and Democracy*. Ed. Pelle Ehn, Elisabet M. Nilsson, and Richard Topgaard, 153-170. Cambridge, MA: MIT Press.

De Carlo, Giancarlo. 1970. Architecture's public. In *Architecture and Participation*. Parametro Magazine. Abingdon: Spon Press, 2007.

de Certeau, Michel. 1984. *The Practice of Everyday Life*. Trans. Steven Rendall Berkeley: University of California Press.

Dablanc, Laetitia. 2007. Goods transport in large european cities: Difficult to organize, difficult to modernize. *Transportation Research Part A: Policy and Practice* 41 (3): 280-285.

Davoli, Lorenzo and Christoffel Kuenen. 2013. New participative tools require new foundations. In *10th European Academy of Design Conference-Crafting the Future*, Gothenburg.

Davoli, Lorenzo, Heather Wiltse, and Johan Redström. 2015. Trojans & drones: Materializing possibilities for transforming industrial infrastructures. In *Proceedings of the 2nd Biennial Research Through Design Conference*, Cambridge, UK.

Davoli, Lorenzo, Johan Redström, and Ruben van der Vleuten. 2014. Hacking delivery systems: Exploring design tools for user-led innovation in urban infrastructures. In *Proceeding of the DRS Biennial International Conference, Design's Big Debates*. Umeå, Sweden: Design Research Society.

Davoli, Lorenzo and Johan Redström. 2014. Materializing infrastructures for participatory hacking. In *Proceedings of the 2014 Conference on Designing Interactive Systems*. Vancouver.

Deckers, Eva, Stephan Wensveen, Rene Ahn, and Kees Overbeeke. 2011. Designing for perceptual crossing to improve user involvement. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems.*

Dewey, John. 1954. Search for the great community. In *The Public and Its Problems: An Essay in Political Inquiry*, 143-184. Ohio: Swallow Press.

——— 1987. Art as Experience. In *Art and Its Significance: An Anthology of Aesthetic Theory*. 2nd edition. Ed. Stephen David Ross, 204-220. Albany, NY: SUNY Press.

Dillahunt, Tawanna R and Amelia R Malone. 2015. The promise of the sharing economy among disadvantaged communities. *Ann Arbor* 1001:48105.

Dilnot, Clive. 2015. History, design, futures: Contending with what we have made. In *Design and the Question of History*. Ed. Tony Fry, Lisa Norton, and Anne-Marie Willis, 131-242. London: Bloomsbury Publishing.

DiSalvo, Carl. 2009. Design and the construction of publics. *Design Issues* 25 (1): 48-63.

———. 2012. *Adversarial Design*. Cambridge, MA: The MIT Press.

DiSalvo, Carl, Illah Nourbakhsh, David Holstius, Ayça Akin, and Marti Louw. 2008. The neighborhood networks project: A case study of critical engagement and creative expression through participatory design. In Proceedings of the *Tenth Anniversary Conference on Participatory Design*.

DiSalvo, Carl, Jonathan Lukens, Thomas Lodato, Tom Jenkins, and Tanyoung Kim. 2014. Making public things: How HCI design can express matters of concern. In *Proceedings of the 32nd Annual ACM Conference on Human Factors in Computing Systems*.

DiSalvo, Carl, Marti Louw, David Holstius, Illah Nourbakhsh, and Ayça Akin. 2012. Toward a public rhetoric through participatory design: Critical engagements and creative expression in the neighborhood networks project. *Design Issues* 28 (3): 48-61.

Dourish, Paul. 2004. *Where the Action Is: The Foundations of Embodied Interaction. Cambridge*, MA: MIT Press.

Dourish, Paul and Genevieve Bell. 2007. The infrastructure of experience and the experience of infrastructure: Meaning and structure in everyday encounters with space. *Environment and Planning B: Planning and Design* 34 (3): 414-430.

Dunne, Anthony. 2008. Hertzian Tales: Electronic Products, Aesthetic Experience, And Critical Design. In *Hertzian Tales: Electronic Products, Aesthetic Experience, and Critical Design*. Cambridge, MA: The MIT Press.

Dunne, Anthony and Fiona Raby. 2001. *Design Noir: The Secret Life of Electronic Objects*. London: Springer.

———. 2013. *Speculative Everything: Design, Fiction, and Social Dreaming.* Cambridge, MA: MIT Press.

Dunne, Anthony and William W. Gaver. 1997. The pillow: Artist-Designers in the digital age. In *Extended Abstracts on Human Factors in Computing Systems*. Atlanta, Georgia.

Dyrssen, Cahtarina. 2010. Navigating into heterogeneity: Architectural thinking as research. *In The Routledge Companion to Research in the Arts*. Ed. Mark Biggs and Karlsson Henrik, 223-239. London & New York: Routledge.

Eagle, Nathan and Alex Pentland. 2006. Reality mining: Sensing complex social systems. *Personal and Ubiquitous Computing* 10 (4): 255-268.

Easterling, Keller. 2012. An internet of things. *E-flux Magazine* 31 (1).

———. 2014. *Extrastatecraft: The Power of Infrastructure Space*. London: Verso Books.

Edwards, Paul N. 2003. Infrastructure and modernity: Force, time, and social organization in the history of sociotechnical systems. *Modernity and Technology* 185-225.

Ehn, Pelle. 1988. "Work-oriented design of computer artifacts". PhD diss., Arbetslivscentrum.

———. 2008. Participation in design things. In *Proceedings of the Tenth Anniversary Conference on Participatory Design*.

Ehn, Pelle, Elisabet M Nilsson, and Richard Topgaard. 2014. *Making Futures: Marginal Notes on Innovation, Design, and Democracy*. Cambridge, MA: MIT Press.

Farocki, Harun. 1969. *Inextinguishable Fire*. Germany

Feenberg, Andrew. 1990. Post-industrial discourses. *Theory and Society* 19 (6): 709-737.

———. 2000a. Constructivism and technology critique: Replies to critics. *Inquiry* 43 (2): 225-237.

———.2000b. From essentialism to constructivism: Philosophy of technology at the crossroads. In *Technology and the Good Life?* Ed. Eric Higgs, Light Andrew, and Strong David, 294-315. Chicago: University of Chicago Press.

Fiksel, Joseph. 2003. Designing resilient, sustainable systems. *Environmental Science & Technology* 37 (23): 5330-5339.

Fischer, Gerhard and Eric Scharff. 2000. Meta-design: Design for designers. In *Proceedings of the 3rd Conference on Designing Interactive Systems: Processes, Practices, Methods, and Techniques*.

Flores, Fernando. 2000. Heideggerian thinking and the transformation of business practice. In *Heidegger, Coping and Cognitive Science: Essays in Honour of Herbert L. Dreyfus*. Ed. Jeff Malpas and Mark Wrathall. Cambridge, MA: MIT Press

Forlizzi, Jodi and Katja Battarbee. 2004. Understanding experience in interactive systems. In *Proceedings of the 5th Conference on Designing Interactive Systems: Processes, Practices, Methods, and Techniques*.

Foucault, Michel and Jay Miskowiec. 1986. Of other spaces. *Diacritics* 16 (1): 22-27.

Frens, Joep. 2005. A rich user interface for a digital camera. *Pers Ubiquit Comput* 10 (2-3): 177-180.

Friedman, Ken. 2008. Research into, by and for design. *Journal of Visual Art Practice* 7 (2): 153-160.

Fry, Tony. 2009. *Design Futuring: Sustainability, Ethics and New Practice*. Oxford: Berg.

Fuchs, Christian. 2010. Labor In Informational Capitalism And On The Internet. *The Information Society* 26 (3): 179-196

Fuller, Richard Buckminster and Jaime Snyder. 1969. *Operating Manual for Spaceship Earth*. Carbondale: Southern Illinois University Press.

Gaylor, Brett. *Do Not Track Me*. Documentary . Upian, National Film Board of Canada, Arte, Bayerischer Rundfunk, CBC/Radio-Canada. Accessed Jan 4, 2016. www.donottrack-doc.com

Giaccardi, Elisa and Gerhard Fischer. 2008. Creativity and evolution: A metadesign perspective. *Digital Creativity* 19 (1): 19-32.

Gilmore, James and Joseph Pine. 1999. *The Experience Economy: Work Is Theatre and Every Business a Stage*. Boston: Harvard Business School Press.

Graham, Stephen and Simon Marvin. 2001. *Splintering Urbanism, Networked Infrastructures, Technological Mobilities and the Urban Condition*. Oxon: Routledge.

Grauwin, Sébastian, Stanislav Sobolevsky, Simon Moritz, István Gódor, and Carlo Ratti. 2014. Towards A Comparative Science Of Cities: Using Mobile Traffic Records In New York, London And Hong Kong. *ArXiv Preprint ArXiv:1406.4400*.

Hallnäs, Lars and Johan Redström. 2002. From use to presence: On the expressions and aesthetics of everyday computational things. *ACM Transactions on Computer-Human Interaction (TOCHI)* 9 (2): 106-124

Halse, Joachim, Eva Brandt, Brendon Clark, and Thomas Binder. 2010. *Rehearsing the Future*. København: Danish Design School Press.

Haque, Usman. 2002. Hardspace, Softspace And The Possibilities Of Open Source Architecture. www.haque.co.uk.

———. 2010. Notes On The Design Of Participatory Systems - For The City Or For The Planet. *Habitar,* June.

Haraway, Donna Jeanne. 1994. A game of cat's cradle: Science studies, feminist theory, cultural studies. *Configurations* 2 (1): 59-71.

Hardt, Michael and Antonio Negri. 2005. *Multitude War and Democracy in the Age of Empire*. New York: Penguin Books.

Hawken, Paul, Amory B Lovins, and L Hunter Lovins. 2013. *Natural Capitalism: The Next Industrial Revolution*. New York: Beck Bay.

Heidegger, Martin. 1977. The question concerning technology . In *The Question Concerning Technology, and Other Essays*. New York: Harper & Row.

Hesse, Markus. 2002. Shipping news: The implications of electronic commerce for logistics and freight transport. *Resources, Conservation and Recycling* 36 (3): 211-240.

Hesse, Markus and Jean-Paul Rodrigue. 2004. The transport geography of logistics and freight distribution. *Journal of Transport Geography* 12 (3): 171-184.

Hill, Dan. 2012. *Dark Matter and Trojan Horses: A Strategic Design Vocabulary*. Moscow: Strelka Press. PDF e-book.

Hill, Dan and Bryan Boyer. 2013. Brickstarter. Helsinki: SITRA. http://www.brickstarter.org/Brickstarter.pdf.

Hodson, Hal. 2013. Hand-delivered parcels find their way to you via the crowd. *New Scientist* 218 (2917): 17-18.

Holmlid, Stefan. 2007. Interaction design and service design: Expanding a comparison of design disciplines. In *Proceedings of the Second Nordic Design Conference, Design Inquiries*. Stockholm.

———. 2009. Participative, co-operative, emancipatory: From participatory design to service design. In *Proceedings of the First Service Design and Service Innovation Conference, DeThink Service ReThink Design*. Oslo.

Holmlid, Stefan and Shelley Evenson. 2008. Bringing service design to service sciences, management and engineering. In *Service Science, Management and Engineering Education for the 21st Century*. Springer.

Holt, Jennifer and Vonderau Patrick. 2015. "Where the internet lives" data centers as cloud infrastructure. In *Signal Traffic: Critical Studies of Media Infrastructures*. Ed. Lisa Park and Nicole Starosielski, 71-93. University of Illinois Press.

Horkheimer, Max and Theodor W. Adorno. 2002. Enlightenment as mass. Deception. In *Dialectic of Enlightenment*. Ed. Gunzelin Schmid Noerr. Stanford University Press.

Hughes, Thomas P. 1987. The evolution of large technological systems. In *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*. Cambridge, MA: MIT Press, 2012.

Hunt, Jamer. 2005. A manifesto for postindustrial design mass production, as we know it, will soon be extinct. *I.D. Megazine* 52 (8): 120

———. 2011. Prototyping the social: Temporality and speculative futures at the intersection of design and culture. In *Design Anthropology*. New York: Springer.

Ihde, Don. 1993. *Philosophy of Technology: An Introduction*. St. Paul, MN: Paragon House.

Janssens, Nel. 2012. "Utopian-driven projektive research exploring the field of metaurbanism". PhD diss., Chalmers University of Technology.

Jegou, Francois and Ezio Manzini. 2008. *Collaborative Services: Social Innovation and Design for Sustainability*. Edizioni POLI.design.

Jeremijenko, Natalie. Environmental Health Clinic. Accessed Jan 4, 2016. http://www.environmentalhealthclinic.net.

Johansson, Allan, Peter Kisch, and Murat Mirata. 2005. Distributed economies – A new engine for innovation. *Journal of Cleaner Production* 13 (10-11): 971-979.

Johnson, Mark. 2011. Embodied knowing through art. In *The Routledge Companion to Research in the Arts*. Ed. Mark Biggs and Karlsson Henrik, 141-151. London: Routledge.

Jones, John Chris. 1992. *Design Methods*. Hoboken, NJ: John Wiley & Sons.

Kelley, Tom. 2001. *The Art of Innovation: Lessons in Creativity From IDEO, America's Leading Design Firm*. New York: Doubleday.

Kimbell, Lucy. 2009. The turn to service design. In *Design and Creativity: Policy, Management and Practice*. Ed. Guy Julier and Liz Moore, 157-173. Oxford: Berg.

———. 2011a. Designing For Service As One Way Of Designing Services. *International Journal of Design* 5 (2): 41-52.

———. 2011b. Rethinking design thinking: Part I. *Design and Culture* 3 (3): 285-306.

Kirilenko, Andrei A, Albert S Kyle, Mehrdad Samadi, and Tugkan Tuzun. 2014. The flash crash: The impact of high frequency trading on an electronic market. *Available at SSRN 1686004*.

Kirk, Andrew. 2001. Appropriating technology: The whole earth catalog and counterculture environmental politics. *Environmental History* 6 (3): 374-394.

Koehler, Andreas and Claudia Som. 2005. Effects of pervasive computing on sustainable. *Technology and Society Magazine*, *IEEE* 24 (1): 15-23.

Koskinen, Ilpo, John Zimmerman, Thomas Binder, Johan Redstrom, and Stephan Wensveen. 2011. *Design Research Through Practice: From the Lab, Field, and Showroom*. Amsterdam, Elsevier.

Kuniavsky, Mike. 2010. *Smart Things: Ubiquitous Computing User Experience Design*. Amsterdam, Elsevier.

Kuznetsov, Stacey and Eric Paulos. 2010a. Participatory sensing in public spaces: Activating urban surfaces with sensor probes. In *Proceedings of the 8th ACM Conference on Designing Interactive Systems*.

———. 2010b. Rise of the expert amateur: DIY projects, communities, and cultures. In *Proceedings of the 6th Nordic Conference on Human-Computer Interaction: Extending Boundaries*.

Lang, Peter and William Menking. 2003. *Superstudio: Life Without Objects*. Milano: Skira.

Latour, Bruno. 1992. Where are the missing masses? The Sociology of a Few Mundane Artifacts. In *Shaping Technology/Building Society: Studies in Sociotechnical Change*. Ed. Bijker Wiebe E. and John Law, 225-258. Cambridge, MA: MIT Press.

———. 1996. On actor-network theory: A few clarifications. *Soziale Welt* 47:369-381.

———. 2005. *Reassembling the Social-An, Introduction to Actor-Network-Theory*. New York: Oxford University Press.

———. 2010. An attempt at a "Compositionist Manifesto". *New Literary History* 41 (3): 471-490.

Lim, Youn-Kyung, Erik Stolterman, and Josh Tenenberg. 2008. The anatomy of prototypes: Prototypes as filters, prototypes as manifestations of design ideas. *ACM Transactions on Computer-Human Interaction* (TOCHI) 15 (2): 7.

Lindholm, Maria and Sönke Behrends. 2012. Challenges In Urban Freight Transport Planning-A Review In The Baltic Sea Region. *Journal of Transport Geography* 22:129-136.

Lindinger, Herbert. 1990. Ulm: Legend and living idea. In *Ulm Design: The Morality of Objects*. Trans. David Britt Cambridge, MA: MIT Press.

Lovins, Amory B. 1976. Energy Strategy: The Road Not Taken? *Foreign Affairs*, October. https://www.foreignaffairs.com/articles/united-states/1976-10-01/energy-strategy-road-not-taken

Lukens, Jonathan. 2013. DIY Infrastructure And The Scope Of Design Practice. *Design Issues* 29 (3): 14-27.

Luo, Wanying, Qi Xie, and Urs Hengartner. 2009. Facecloak: An Architecture For User Privacy On Social Networking Sites. In *Proceedings of Computational Science and Engineering, International Conference, CSE'09*.

Lyster, Clare. 2012. Learning from fedex: Lessons for the city. *Journal of Landscape Architecture* 7 (1): 54-67.

Maldonado, Tomás. 1958. New developments in industry and the training of designers. *Ulm School's Journal* (2): 25-40.

Manzini, E, Luisa Collina, and Stephen Evans. 2004. *Solution Oriented Partnership, How to Design Industrialized Sustainable Solutions*. UK: Cranfield University.

Manzini, Ezio. 2013. Small, Local, Open and Connected: Resilient Systems and Sustainable Qualities. *Design Observer*, February 6. Accessed October 25, 2015. http://changeobserver.designobserver.com/feature/small-local-open-and-connected-resilient-systems-and-sustainable-qualities/37670/

———.2015. Design, *When Everybody Designs: An Introduction to Design for Social Innovation*. Trans. Rachel Coad Cambridge, MA: MIT Press.

Manzini, Ezio and Carlo Vezzoli. 2003. Product-service Systems and Sustainability: Opportunities for Solutions. UNEP, Division of Technology Industry and Economics, Production and Consumption Branch.

Manzini, Ezio and François Jegou. 2003. Sustainable everyday-scenarios, visions, possible worlds. *Design Philosophy Papers*, no. 4.

Marcuse, Herbert. 1991. *One-dimensional Man: Studies in the Ideology of Advanced Industrial Society*. Boston: Beacon Press.

Margolin, Victor. 2002. *The Politics of the Artificial: Essays on Design and Design Studies*. Chicago: University of Chicago Press.

Mattelmäki, Tuuli. 2005. Applying probes, from inspirational notes to collaborative insights. *CoDesign* 1 (2): 83-102.

McBay, Conor, Gerard Parr, and Sally McClean. 2014. Sustainable Communications Infrastructures In The Cloud-Supporting The Information Economy. In *Proceedings of the 2014 IEEE/ACM 7th International Conference on Utility and Cloud Computing*..

McCullough, Malcolm. 2005. *Digital Ground: Architecture, Pervasive Computing, and Environmental Knowing*. Cambridge MA: MIT Press.

Meadows, Donella and Dianne Wright. 2008. *Thinking in Systems*. Chelsea Green Publishing.

Meadows, Donella H, Dennis L Meadows, Jorgen Randers, and Williams W Behrens. 1972. *The limits to growth*. New York: Universe Books.

Merleau-Ponty, Maurice. 1968. The visible and the invisible. In *Maurice Merleau-Ponty: Basic Writings*. Ed. Thomas Baldwin. Routledge, 2004.

Meroni, Anna. 2007. *Creative Communities: People Inventing Sustainable Ways of Living*. Edizioni POLI.design.

Meroni, Anna and Daniela Sangiorgi. 2011. *Design for Services*. Gower Publishing,

Mitchell, William J. 2003. *Me++: The Cyborg Self and the Networked City*. Cambridge, MA: MIT Press.

———. 2005. *Placing Words*. Cambridge, MA: MIT Press.

Moggridge, Bill and Bill Atkinson. 2007. *Designing Interactions*. Cambridge MA: MIT Press.

Morelli, Nicola. 2002. Designing product/service systems: A methodological exploration1. *Design Issues* 18 (3): 3-17.

———. 2007. Social innovation and new industrial contexts: Can designers" industrialize" socially responsible solutions? *Design Issues* 23 (4).

Mouffe, Chantal. 2000. *The Democratic Paradox*. New York, Verso.

Musolesi, Mirco. 2014. Big mobile data mining: Good or evil? *Internet Computing, IEEE* 18 (1): 78-81.

Nancy, Jean-Luc. 2007. *The Creation of the World, or, Globalization*. Albany NY: Suny Press.

Nelson, Harold G and Erik Stolterman. 2003. *The Design Way: Intentional Change in An Unpredictable World. Foundations and Fundamentals of Design Competence*. Englewood Cliffs, NJ: Educational Technology.

Nietzsche, Friedric. 1976. The Antichrist. In *The Portable Nietzsche*. London: Penguin.

Noble, David F. 1979. *America by Design: Science, Technology, and the Rise of Corporate Capitalism*. Oxford University Press.

O'Connor, Brendand. Creepy DOL. Accessed August 27, 2015. http://blog.ussjoin.com/2013/08/creepydol.html

Odom, William, John Zimmerman, Scott Davidoff, Jodi Forlizzi, Anind K Dey, and Min Kyung Lee. 2012. A fieldwork of the future with user enactments. In *Proceedings of the Designing Interactive Systems Conference*.

Odum, Howard T and Richard C Pinkerton. 1955. Time's speed regulator: The optimum efficiency for maximum power output in physical and biological systems. *American Scientist* 331-343.

Offenhuber, Dietmar, David Lee, Malima I Wolf, Santi Phithakkitnukoon, Assaf Biderman, and Carlo Ratti. 2012. Putting matter in place: Measuring tradeoffs in waste disposal and recycling. *Journal of the American Planning Association* 78 (2): 173-196.

Offenhuber, Dietmar and David Lee. 2012. Putting the informal on the map: Tools for participatory waste management. In *Proceedings of the 12th Participatory Design Conference: Exploratory Papers, Workshop Descriptions, Industry Cases-Volume 2*.

Olivetti, Adriano. 1946. *L'ordine Politico Delle Comunità* [The Political Order of Communities] . Ed. Davide Cadeddu. Edizioni di Comunità, 2014. PDF e-book.

"OpenXC.". Ford OpenXC Platform. http://openxcplatform.com/

O'Connor, Brendand. 2014. WHOOPS!. *The SciTech Lawyer* Volume 10, (Issue 2,).

Papanek, Victor. 1971. *Design for the Real World, Human Ecology and Social Change*. London: Thames & Hudson , 2011.

Pask, Gordon. 1975. *Conversation, Cognition and Learning*. Amsterdam: Elsevier.

Pasquale, Frank. 2015. *The Black Box Society: The Secret Algorithms That Control Money and Information*. Cambridge MA: Harvard University Press.

Pevsner, Nikolaus. 1936. The modern movement before nineteen-fourteen, from pioneers of modern design . In *The Design History Reader*. Ed. Grace Lees Maffei and Rebecca Houze, 104-108. London: Bloomsbury, 2010.

Pierce, James and Eric Paulos. 2015. Making multiple uses of the obscura 1C digital camera: Reflecting on the design, production, packaging and distribution of a counterfunctional device. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*.

Piketty, Thomas. 2014. *Capital in the 21st Century*. Cambridge, MA: Harvard University Press.

Qiu, Jack Linchuan, Melissa Gregg, and Kate Crawford. 2014. Circuits of labour: A labour theory of the iphone era. *TripleC: Communication, Capitalism & Critique. Open Access Journal for a Global Sustainable Information Society* 12 (2): 564-581.

Ratti, Carlo and Anthony Townsend. 2011. The social nexus. *Scientific American* 305 (3): 42-48.

Ratti, Carlo and Matthew Claudel. 2015. *Open Source Architecture*. London: Thames & Hudson.

Redström, Johan. 2006. Towards user design? On The Shift From Object To User As The Subject Of Design. *Design Studies* 27 (2): 123-139.

———. 2008. RE: Definitions of use. *Design Studies* 29 (4): 410-423.

———. 2011. Some Notes On Programme-Experiment Dialectics. In *Proceedings of the Fourth Nordic Design Conference, Making Design Matter*. Helsinki.

Rittel, Horst WJ and Melvin M Webber. 1973. Dilemmas In A General Theory Of Planning. *Policy Sciences* 4 (2): 155-169.

Rojas, Francisca M, Kristian Kloeckl, and Carlo Ratti. 2008. Dynamic City: Investigations into the sensing, analysis, and applications of real-time, location-based data. In *Proceedings of Harvard GSD Critical Digital Conference*. Cambridge.

Routarinne, Sara and Johan Redström. 2007. Domestication As Design Intervention. In *Proceedings of the Second Nordic Design Conference, Design Inquiries*. Stockholm. http://www.johan.redstrom.se/papers/domestication.pdf.

Sadler, Simon. 2005. *Archigram: Architecture Without Architecture*. Cambridge, MA: MIT Press.

Saifuzzaman, Mohammad, Md Mazharul Haque, Zuduo Zheng, and Simon Washington. 2015. Impact Of Mobile Phone Use On Car-Following Behaviour Of Young Drivers. *Accid Anal Prev* 82:10-9.

Sanders, EB-N. 2000. Generative tools for co-designing. In *Collaborative Design*. Ed. Linden J Ball and Andreé Woodcock. London: Springer.

Sanders, Elizabeth B-N and Pieter Jan Stappers. 2008. Co-Creation and the new landscapes of design. *CoDesign* 4 (1): 5-18.

———. 2014. Probes, toolkits and prototypes: Three Approaches To Making In Codesigning. *CoDesign* 10 (1): 5-14.

Sangiorgi, Daniela. 2011. Transformative services and transformation design. *International Journal of Design* 5 (2): 29-40.

Sangiorgi, Daniela and Brendon Clark. 2004. Toward a participatory design approach to service design. In *Proceedings of the Eighth Conference on Participatory Design*. Toronto.

Sangiorgi, Daniela and Sabine Junginger. 2015. Emerging issues in service design. *The Design Journal* 18 (2): 165-170.

Sassen, Saskia. 2011. Talking Back to Your Intelligent City. McKinsey.

———. 2014. *Expulsions*. Cambridge, MA: Harvard University Press.

Schaffers, Hans, Carlo Ratti, and Nicos Komninos. 2012. Special Issue On Smart Applications For Smart Cities - New Approaches To Innovation: Guest editors' introduction. *Journal of Theoretical and Applied Electronic Commerce Research* 7 (3): 9-10.

Schön, Donald A. 1995. *The Reflective Practitioner: How Professionals Think in Action*. Farnham: Ashgate.

Schumacher, Ernst Friedrich. 1973. *Small Is Beautiful: A Study of Economics As If People Mattered*. New York: Random House, 2011.

Seago, Alex and Anthony Dunne. 1999. New methodologies in art and design research: The object as discourse. *Design Issues* 15 (2): 11-17.

Sengers, Phoebe and Bill Gaver. 2006. Staying open to interpretation: Engaging multiple meanings in design and evaluation. In *Proceedings of the 6th Conference on Designing Interactive Systems*.

Shannon, Claude Elwood. 2001. A mathematical theory of communication. *ACM SIGMOBILE Mobile Computing and Communications Review* 5 (1): 3-55.

Shedroff, Nathan. 2001. *Experience Design*. Indianapolis: New Riders.

Shepard, Mark. 2009. Sentient city survival kit: Archaeology of the near future. *Digital Arts and Culture*.

Shilton, Katie, Nithya Ramanathan, Sasank Reddy, Vidyut Samanta, Jeff Burke, Deborah Estrin, Mark Hansen, and M Srivastava. 2008. Participatory Design Of Sensing Networks: Strengths And Challenges. In *Proceedings of the Tenth Anniversary Conference on Participatory Design*.

Simon, Herbert A. 1996. *The Sciences of the Artificial*. Cambridge, MA: MIT Press.

Sparke, Penny. 1982. *Ettore Sottsass Jnr*. London: Design Council.

Star, Susan Leigh and Karen Rohleder. 1996. Steps Toward An Ecology Of Infrastructure: Design and access for large information spaces. *Information Systems Research* 7 (1): 111-134.

Starosielski, Nicole. 2015. "Fixed flow" undersea cables as media infrastructures. In *Signal Traffic: Critical Studies of Media Infrastructures*. Ed. Lisa Park and Nicole Starosielski, 53-70. Urbana: University of Illinois Press.

Steenson, Molly Wright. 2014. "Architectures Of Information: Christopher Alexander, Cedric Price, And Nicholas Negroponte And MIT's Architecture Machine Group". PhD diss., Princeton University.

Suchman, Lucy. 1987. *Plans and Situated Actions: The Problem of Human-machine Communication*. Cambridge: Cambridge University Press.

———. 1995. Making work visible. *Communications of the ACM* 38 (9): 56-64.

———. 2008. Striking likeness to difference. *4S/EASST*. Rotterdam

Suchman, Lucy. 2012. Configuration. In *Inventive Methods: The Happening of the Social*. Ed. Celia Lury and Nina Wakeford, 48-60. London: Routledge

Sundararajan, Arun. 2013. From Zipcar to the Sharing Economy. *Harvard Business Review*, January 03. https://hbr.org/2013/01/from-zipcar-to-the-sharing-eco

Szymanski, Margaret and Jack Whalen. 2011. *Making Work Visible: Ethnographically Grounded Case Studies of Work Practice*. Cambridge: Cambridge University Press.

Terranova, Tiziana. 2000. Free labor: Producing culture for the digital economy. *Social Text* 18 (2): 33-58.

Thackara, John. 1988. Beyond the object in design. In *Design After Modernism*. London: Thames and Hudson

———. 2006. *In the Bubble: Designing in a Complex World*. Cambridge, MA: MIT Press.

Tonkinwise, Cameron. 2011. A taste for practices: Unrepressing style in design thinking. *Design Studies* 32 (6): 533-545.

Townsend, Anthony, R. Maguire, M. Liebhold, and M. Crawford. 2011. *The Future of Cities Information, and Inclusion*. A planet of civic laboratories. Palo Alto: Institute of the Future.

Townsend, Anthony M. 2013. *Smart Cities: Big Data, Civic Hackers, and the Quest for a New Utopia*. New York: WW Norton & Company.

Tracy, David. 1994. *Plurality and Ambiguity: Hermeneutics, Religion, Hope*. Chicago: University of Chicago Press.

Turner, Fred. 2010. *From Counterculture to Cyberculture: Stewart Brand, the Whole Earth Network, and the Rise of Digital Utopianism*. Chicago: University Of Chicago Press.

Verbeek, Peter-Paul. 2006. Materializing morality design ethics and technological mediation. *Science, Technology & Human Values* 31 (3): 361-380.

———. 2010. *What Things Do: Philosophical Reflections on Technology, Agency, and Design*. Penn State Press.

———. 2011. *Moralizing Technology: Understanding and Designing the Morality of Things*. Chicago: University of Chicago Press.

Verbeek, Peter-Paul and Petran Kockelkoren. 1998. The things that matter. author(s): Peter-Paul verbeek and petran kockelkoren. Design Issues 14 :28-42

Verganti, Roberto. 2009. *Design driven innovation. In Design Driven Innovation*. Boston: Harvard Business School Press.

Vezzoli, Carlo, Fabrizio Ceschin, and René Kemp. 2008. Designing transition paths for the diffusion of sustainable system innovations. A new potential role for design in transition management? In *Changing the Change. Design, Visions, Proposals and Tools*. Torino: Allemandi.

Vezzoli, Carlo, Kristjan Pruul, and Rachel Coad. 2010. *System Design for Sustainability: Theory, Methods and Tools for a Sustainable "Satisfaction-system"* Design. Maggioli Editore.

Vitali, Stefania, James B. Glattfelder, and Stefano Battiston. 2011. The network of global corporate control. *PLoS One*, no. 6(10) doi:10.1371/journal.pone.0025995. http://www.plosone.org/article/citationList.action?articleURI=info%3Adoi%2F10.1371/journal.pone.0025995.

Vitta, Maurizio. 2001. *Il Progetto Della Bellezza: Il Design Fra Arte E Tecnica*, 1851-2001. Piccola Biblioteca Einaudi.

Von Busch, Otto. 2009. Engaged design and the practice of fashion hacking. *Fashion Practice* 1 (2): 163–186.

Von Hippel, Eric. 2009. Democratizing innovation: The evolving phenomenon of user innovation. *International Journal of Innovation* Science 1 (1): 29-40.

Weber, Samuel and Wlad Godzich. 1987. *Institution and Interpretation*. University of Minnesota Press Minneapolis.

Weiser, Mark. 1993. Some computer science issues in ubiquitous computing. *Communications of the ACM* 36 (7): 75-84.

Wiener, Norbert. 1961. *Cybernetics or Control and Communication in the Animal and the Machine*. Cambridge, MA: MIT Press.

Winner, Langdon. 1989. *The Whale and the Reactor. A Search for the Limits in the Age of High Technology*. Chicago: University of Chicago Press.

"World Bank National Accounts Data, and OECD National Accounts Data Files". World Development Indicators. World Bank. Accessed January 20, 2016. http://data.worldbank.org/indicator/NV.SRV.TETC.ZS

Zervas, Georgios, Davide Proserpio, and John Byers. 2014. The rise of the sharing economy: Estimating the impact of airbnb on the hotel industry. *Boston University School of Management Research Paper*, no. 2013-16.

Zomerdijk, L. G. and C. A. Voss. 2009. Service design for experience-centric services. *Journal of Service Research* 13 (1): 67-82.