TreeHugger: The Eco-Systemic Prototypical Urban Intervention

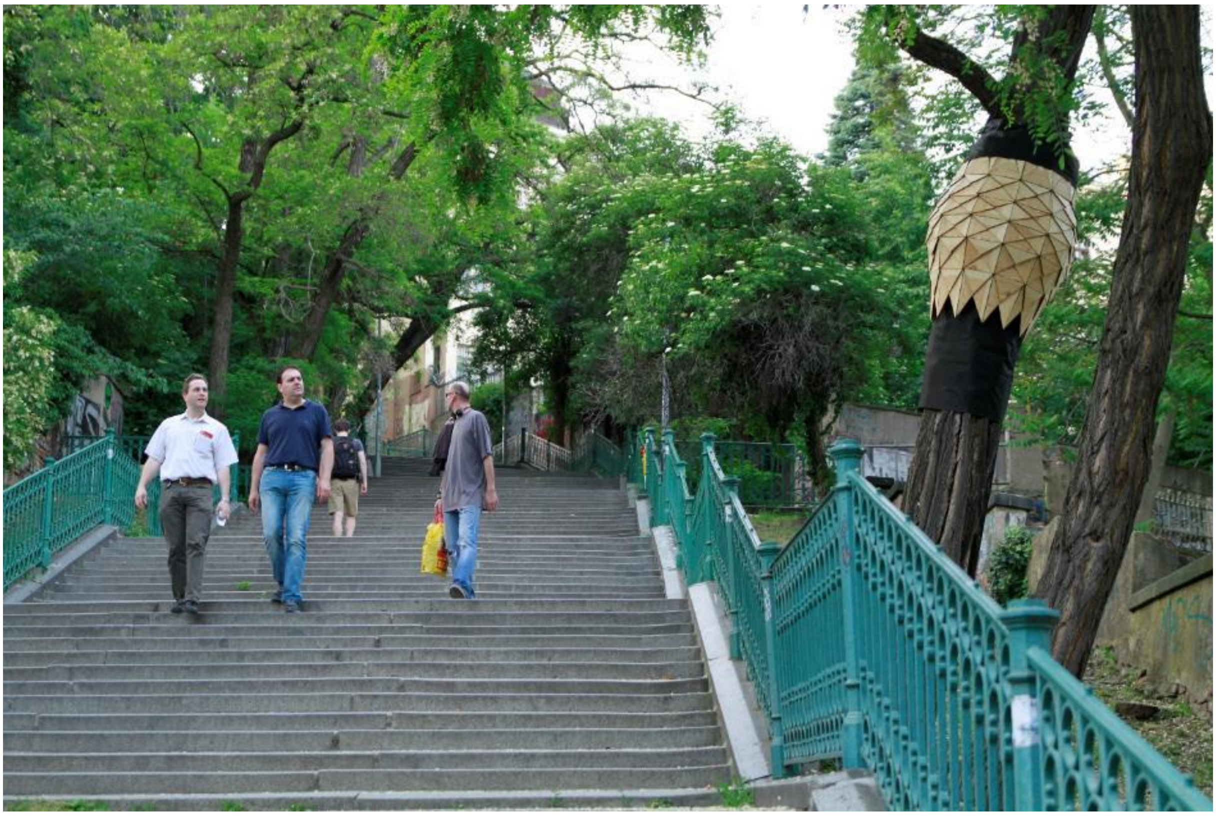

Figure 1: TreeHugger Insect Hotel Eco-Systemic Prototypical Urban Intervention Attracting the Public Attention (photo: Carrithers 2017)

The paper discusses co-design, development, production, application of TreeHugger (see Figure 1). The co-design among community and tran-sdisciplinary participants with different expertise required scope of media mix, switching between analogue, digital and back again. This involves different degrees of physical and digital 'GIGA-Mapping' (Sevaldson, 2011, 2015)*,* 'Grasshopper3d' (Davidson, 2017) *scripting and mix of digital and analogue fabrication to address the real life world. The critical participation of this* 'Time-Based Design' (Sevaldson, 2004, 2005) *process is the interaction of the prototype with eco-systemic agency of the adjacent environment – the eco-systemic performance. The TreeHugger is a responsive solid wood insect hotel, generating habitats and edible landscaping* (Creasy, 2004) *on bio-tope in city centre of Prague. To extend the impact, the code was uploaded for communities to download, local-specifically edit and apply worldwide. Thus, the fusion of discussed processes is multi-scaled and multi-layered, utilised in emerging design field: Systemic Approach to Architectural Performance.*

Keywords: eco-systemic urban prototypical interventions, eco-systemic performance, eco-systemic agency, giga-mapping, full-scale prototyping, grasshopper, responsive wood,

systemic approach to architectural performance

1 Introduction

The project COLridor (Davidová, 2017), where the TreeHugger (see Figure 1) is a first prototype, engaged cooperation of Collaborative Collective NGO, CooLAND NGO, Faculty of Art and Architecture at the Technical University of Liberec, Faculty of Forestry and Wood Sciences at the Czech University of Life Sciences in Prague and the local community biotic and abiotic agency, including humans. The paper covers a fusion of several process based fields, namely *'Systems Oriented Design'*, *'Performance Oriented Architecture*', *'Time-Based Design'* and in this sense *'Prototypical Urban Interventions',* while performing as *'Service Design'* and co-design and co-creation. We have to, at least shortly, address all of these because within this work these fields have been fused from eco-systemic, process-based perspective into one new emerging design field ratified in 2017 by the first author in her PhD thesis as 'Systemic Approach to Architectural Performance' (Davidová, 2017c). SAAP develops methodology and generates theory through experimental practice. It involves Time Based Eco-Systemic Co-Design performed by both biotic and abiotic agency. It belongs to a broader field of Systemic Design, while considering the overall eco-system in action. It is reached through engagement of eco-systemic *'prototypical urban interventions'* (Doherty, 2005), thus interaction with- and integration in- the (eco)system. Therefore, we cannot really differentiate the methodology from so-called 'result' as the result is an over-evolving performative design process. For this reason, the section 2 and section 3 as well as a concluding part are in the process of feedback looping.

1.1 Systems Oriented Design

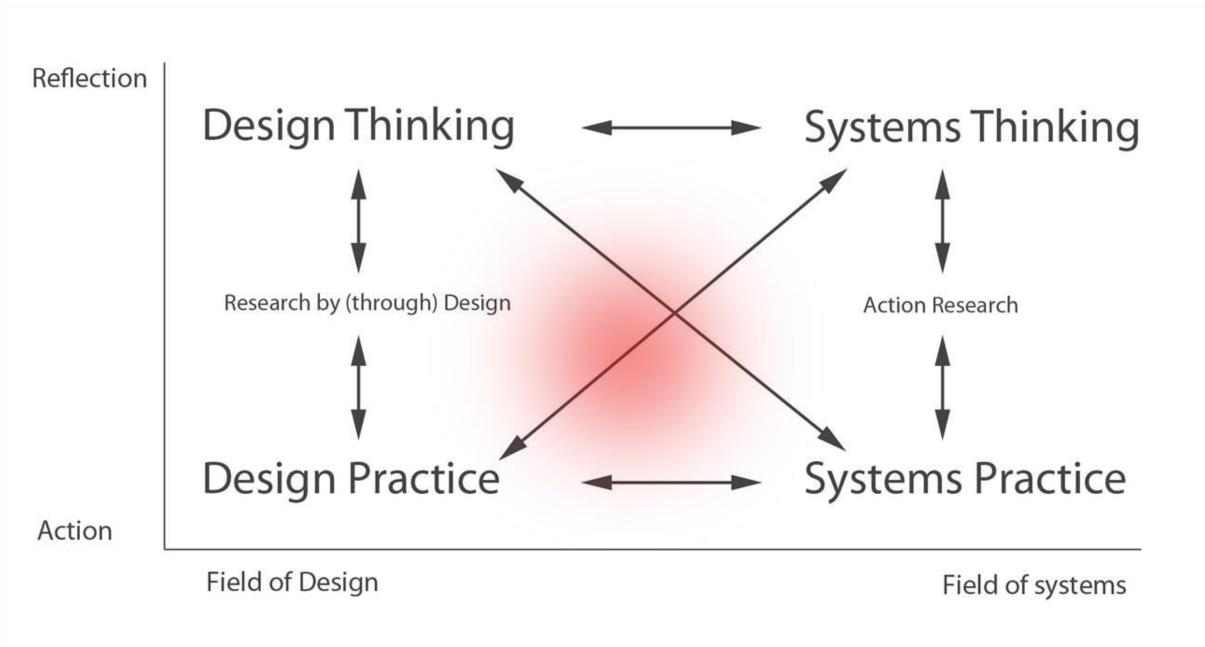

Figure 2: Field of Possibilities in Systemic Design. Systems Oriented Design is Located at the Red Dot. (Sevaldson, 2013) – *publishing with the courtesy of Sevaldson*

The methodology discussed here originates from Systems Oriented Design founded around 2006 by Birger Sevaldson. SOD is the most designerly and practice oriented way to deal with systemic relations (Sevaldson, 2017a) (see Figure 2). SOD namely bases in the trans-disciplinary design process tool called GIGA-Mapping which we discuss in more detail in the Methodology: Analogue and Digital Co-Creation section 2, namely in the GIGA-Mapping Co-Design subsection 2.1. It is an unbounded visual diagramming of complexity of different scales and layers. As we see in following text, it can perform well as a co-design (– subsection 1.6 and 2.1) tool among community, digital designers (– subsection 2.2) and other professions. SOD is used and developed in many design fields, namely in a very process based field of Service Design. (– subsection 1.5). Therefore, there is very short and beneficial connection to relate to our process based design of co-designing co-performances and co-living for SOD references.

1.2 Performance Oriented Architecture

Performance in architecture (therefore Performance Oriented Architecture) was reformulated by Hensel in 2010 as a reconsolidation of form and function into synergy of dynamics of natural, cultural and social environments (Hensel, 2010). Crucial for this field is full-scale prototyping of material performance and the non-anthropocentric architecture or design (Hensel, 2012, 2013). Our approach is to see these synergetic performative processes as the processes of co-design (see Co-Design and Co-Creation 1.6 subsection) with the overall eco-system, including humans. The eco-systemic co-design, co-creation and co-habitation in architecture has been, by now, mainly discussed as 'weathering' (Mostafavi & Leatherbarrow, 1993). However, this has been done mostly from anthropocentric perspective.

1.3 Time-Based Design

The above discussed is happening in- and needs to deal with- time. Sevaldson explains Time-Based Design as an approach that leads towards understanding action, performance and life cycles (Sevaldson, 2005). Through GIGA-Mapping (– subsection 1.1 and 2.1), full-scale prototyping (– subsection 1.2 and 2.3 and section 3) and the placement of these as performative prototypes into public space as Prototypical Urban Interventions (– subsection 1.4 and 3.2), we believe to rise this understanding while co-designing, co-creating (– subsection 1.6 and section 3) and co-living actions, performance and life cycles with the overall eco-system.

1.4 Prototypical Urban Interventions

Prototypical Urban Interventions were established by CHORA at the start of millennium (CHORA, 2017). These perform the agency as landscape design interventions that trigger other processes and events, through a planning and design methodology. It is questioning the master planning in favour of an indeterminate approach (see 1.3 Time-Based Design). Therefore, it is calling for urban adaptation. The answer is in the level of contextual networking in a project. It is tapping into the rhizomatic and networked landscape and designing with it (Doherty, 2005). We add to this performance oriented time-based approach the view that we are not intervening the urban environment only from anthropocentric perspective. Through the nature of our prototypes (see subsections 1.2 and 2.3 and section 3), we claim to interact with the overall (eco)system. While doing so, we claim it to co-create and co-design, therefore to re-design it.

1.5 Service Design

Stickdorn and Schneider explain the field as a cross-disciplinary practice that works with systems and processes and is aimed at providing holistic service to user. They point out that variety of services have been performed and organised since time immemorial. However, they claim that the field today offers consciously designed services that incorporate new business models that are empathetic to user needs and attempt to create new socio-economic value in society (Copenhagen Institute of Interaction Design, 2008; Stickdorn & Schneider, 2011). We do not feet very comfortable with this discussed conciseness in designing. As we discuss in 2.1 GIGA-Mapping Co-Design, we believe a lot of intuition and sub-consciousness needs to be employed when dealing with systemic design. This comes especially when co-designing with eco-system. However, the field is very advanced in SOD application, cross-disciplinarily, systems and processes development and holistic orientation from which our work benefit when designing systemic interventions and offering DIY services for local specific co-design (– subsection 3.2).

1.6 Co-Design and Co-Creation

The division between *'participatory design'* and *'co-design'* was explained by Sanders and Stappers, where participation means that the related stakeholders are invited to the discussion board, while co-design means *'co-creation'* (Sanders & Stappers, 2008) where the stakeholders play a creative active role within the design process as co-authors. However, in present text, both terms are used in the means of co-creation, discussing the participation in co-design. In presented methodology, the participants have their roles, expertise, cycles and privileges in different events of the time-based (– subsection 1.3) co-creation of eco-systemic performance (see all parts of the paper).

2 Methodology: Analogue and Digital Co-Creation

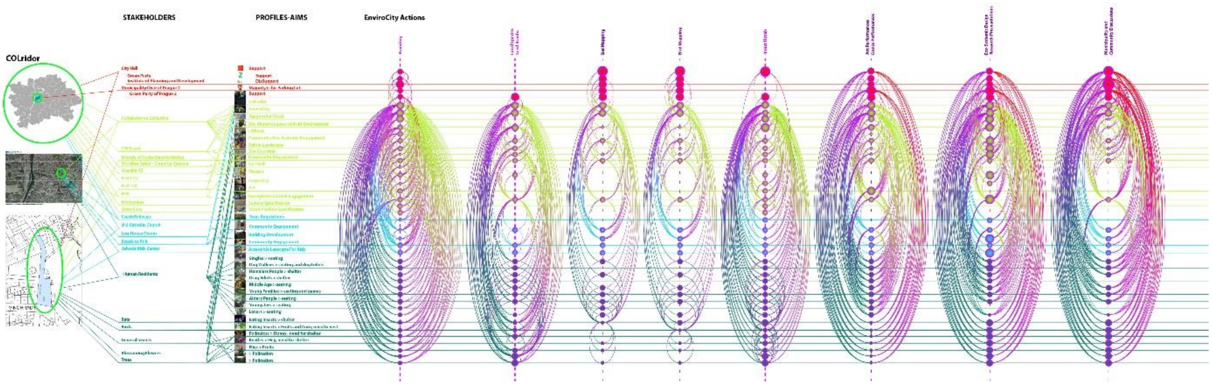

Figure 3: The Exhibition and Public Communication GIGA-Map (Davidová 2017)

The methodology covers creative media mix of analogue and digital. This needs to be adapted to trans-disciplinary and community participation when designing. This methodology has been examined by the first author in an article *'Systemic Approach to Architectural Performance: The Media Mix in the Creative Design Process'* (Davidová, 2017b), focusing namely on GIGA-Mapping and full scale prototyping, while opening the discussion towards participation. This project aimed to take several steps forward in this discussion, proving that GIGA-Map (see Figure 3) might be a crucial tool to utilize these processes. The most important point to mention here is, that the 'design result', the section three (Methodology: The Responsive Wood Insect Hotel), is considered as a design process of the eco-systemic performance, therefore the crucial methodology as well. All of these layers of processes are therefore endlessly feedback looping.

2.1 GIGA-Mapping Co-Design

Figure 4: The Early Stage of Second Community Co-Design GIGA-Mapping Workshop (Photo: Davidová 2017)

The community and trans-disciplinary design processes need to cover complex, yet not organized information, relevant to vide range of participants. All these participants have different communication and design tool preferences and skills. Therefore, visual information that communicates various individuals' tools outputs needs to be cross-referenced and based on that evolved. Therefore, we developed a special case of GIGA-Mapping. While, GIGA-Mapping is defined as a most designerly way to deal with complexity, using visual diagramming (Sevaldson, 2011) and use of generated images and photography has been introduced by the authors some time ago (Davidová, 2007, 2014, 2016b, 2017b), this project introduced the mapping of such across the community together with the trans-disciplinary team. This approach proved that such visual communication performs well across the disciplines, stakeholders and engaged community, as people often easier understand image than words, however they might not master drawing and drawing reading skills. This is because the image is engaging both, the experience and the imagination on tacit and intuitive level while it enables to map such collective relations. Please, see Figure 4 with an early stage of second community co-design GIGA-Mapping workshop, when all the participants were asked for printing out their stakeholder's or professional interests references to be cross-Referenced and drawn upon. The media mixed GIGA-Maps were feedback loopingly reworked and updated from workshop to workshop and by other processed methodologies to digital versions for receiving new and new analogue layers (see Figure 5).

Figure 5: Detail of GIGA-Map That Was Based on Digital Preprint Resulting from Previous Session (Photo: Davidová 2017)

Sevaldson discussed the need of ethics for the situation when certain stakeholders cannot be represented in GIGA-Mapping process (Sevaldson, 2017b). In this case, this was resolved by trans-disciplinary team acting on behalf of such stakeholders (i.e. ecologist on behalf of endangered species). Therefore, the GIGA-Mapping was utilising and relating all the other performed design processes with its specialists' design tools and expertise across the mapping and represented integrated stakeholders' and disciplines' interests. These processes, plans and speculations were afterwards digitally GIGA-Mapped for exhibition and public communication purposes (see Figure 3).

2.2 Grasshopper Script Development

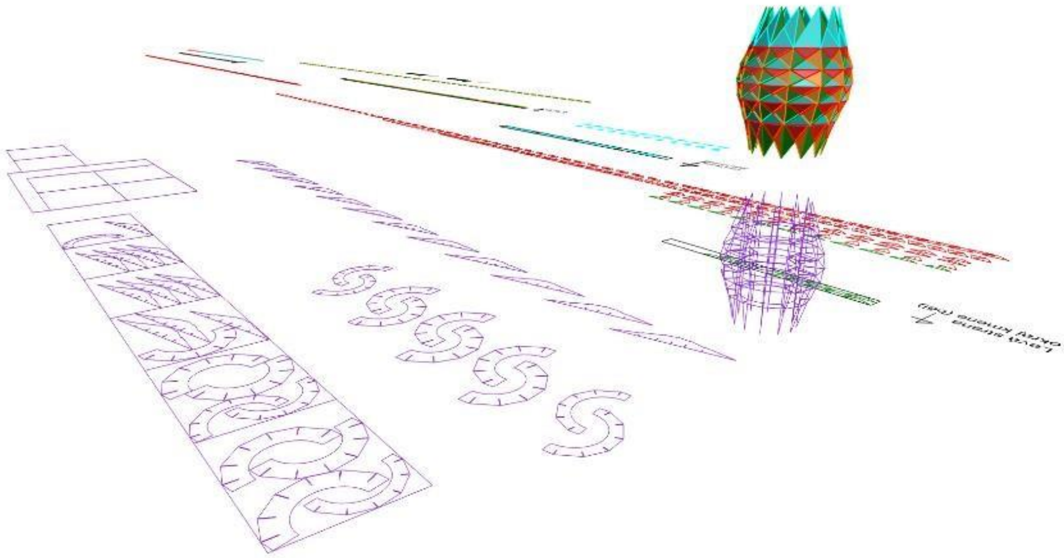

Figure 6: TreeHugger Final Production Drawings Organised with Nesting Tools (image: Prokop 2017)

The Grasshopper coding of the TreeHugger prototype (see Figure 1) was investigating several tools such as LunchBox script (Providing Ground, 2017) and the inbuilt Grasshopper component called Box Slids (Rodkirks & Heumann, 2018) to solve the modelling issues. However, custom made scripts had to be used at the end as any of the released solutions was not suitable. For their development, GIGA-mapping was used to communicate and resolve the intricacies of the three-plane panelling and other problems across the expert team. In some cases, only an analogue model or prototyping was able to display the nature of the problematique. The final structure was changed several times within the design process based on the prototyping even in prototype's finalizing state (see Figure 6).

In the beginning, the LunchBox plugin (Providing Ground, 2017) was used to generate the diamond-like divisions of the reference surface. However, due to the behaviour of LunchBox's script near the seam of the surface a custom script had to be written for the sake of simplifying the top and bottom parts. Such panelling was leveraging the fact that whole bearing construction was also fabricated digitally on a laser cutter. This approach allowed for lowering every next layer of panels so that the overlay was kept by tilting the panels slightly in a vertical manner. The relationship between the loadbearing structure and infilling panels is reciprocal, not hierarchical like architects used to think before digital fabrication.

The structure itself was a simple waffle script which again tested the inbuilt Grasshopper component called Box Slids (Rodkirks & Heumann, 2018). Intersecting first the boxes and then try to cut them into proper shape revealed as not such successful approach. Therefore, first the exact shapes were created and extruded and a custom intersecting script was used. The final shape of the structure was changed just 5 days before the construction date due to unrealistic estimation of wood bending during the design process.

The most critical coding and geometrical challenge of the TreeHugger design was to provide triangular panels facing all four UV directions on a double curved surface and to keep overlaying of their parts to keep rainwater out, the strength of the Ray design (Davidová, 2013, 2016a) (see Figure 10). This was also exemplified on an example of planarization task, where representing a given reference shape is done by a mesh with planar quadrilateral faces (Jiang, Tang, Tomičíc, Wallner, & Pottmann, 2015). However, Ray panelling system operates at three different planes due to panel overlaps. This complicated the whole task of planarization. Finally, for each planar face of the reference surface, three planes were established and panels were distributed accordingly to the flow of rainwater. However, the final state of this code was resolved during the final prototyping after the waffle script structural base was produced and physically investigated.

2.3 Analogue and Digital Fabrication Combination

Figure 7: The Final Adjustments of the Prototype (Photo: Davidová 2017)

The process of designing the TreeHugger (see Figure 1) involved a few structural and conceptual shifts that had to be implemented by the digital model almost immediately. Without the parametric approach provided by use of Grasshopper, such changes would take weeks to remodel in the full scope of the project. First ideas leaned towards a very light bent structure made from thin strips of solid wood, which should had been covered by the performative panels. To apply proper bending, a formwork was developed from ply-wood boards using a simple waffle script. The wooden strips were wrapped around it and fixed by screws (see Figure 8). Although this approach was considered to be feasible by the wood engineering experts, the designers were very suspicious through their intuition and this proved to be correct as the screws were leaping out and we registered several cracks in wooden strips.

Figure 8: The Prototype Trial that Structurally Failed to Perform (Photo: Davidová 2017)

The team decided to redesign structure using ply-wood board waffle as the main structure instead of the bent solid wood strips. The script had to be rewritten in one 4-hour session and the rest of the more or less critical design changes were creatively handled through analogue improvisation in the workshop (see Figure 9) as there was no way to obtain new material and to extend the deadline. I.e. the 0.5 cm thin large ply-wood boards were bending in laser cutting machine when the design was cut. Therefore, some parts had to be resolved by handsaw.

Figure 9: The Waffle Structure with on Place Improvised Wooden Slats to Fix the Panels (Photo: Prokop 2017)

An example of a critical point was the locking of the two halves of the prototype that had to fit with the tree trunk. The to the prototype central trunk was modelled in simplified manner as a cylinder with two different approximate perimeters and the prototype was adjusted manually on place to fit the real nature of the tree (see Figure 7). The digital solution would include 3D scanning of a large portion of the trunk and restoring the resulting mesh. However, this would have to be afterwards anyway optimised to a manageable vertex count with similar result as the first solution. Instead, the approximation along with a simple physical measurement was less time and technology consuming and more efficient when customising in real life situation the analogue way.

3 Methodology: The Responsive Wood Insect Hotel

This prototype is to real life co-design the eco-systemic performance with biotic and abiotic agency of its environment. This covers cross-species habitation, nutrients and social and cultural performance in variety of scales. With the today decrease of biodiversity and biomass in agricultural land due to pests, herbicides, etc., we fight to adapt our cities for the species that started to inhabit them, leaving mentioned toxified land. This certainly cannot happen without human inhabitants accepting and adapting to these settings of co-living situation. Therefore, we no longer design for- but we aim to design with- the overall eco-system (including humans) as an ever-evolving design process.

3.1 The Responsive Wood Prototype TreeHugger

Figure 10: Ray 2 Responsive Wood Envelope Prototype

The prototype has benefited from- and has developed the- concept of *'responsive wood'* (Hensel & Menges, 2006), in this case applying solid wood concept of tangential section observed on Norwegian traditional architectural panelling (Larsen & Marstein, 2000). It is applying first author's research in this field on a screen that airs in dry and hot while enclosing itself in humid and cold climate, Ray (see Figure 10). TreeHugger is a first contemporary built dwelling using this feature. As the performance of the solid wood panels cut from the centre of the trunk have larger warping than those from the edge (Hoadley, 1980), the prototype not only allows their overlapping, but also enables the design of variety of climatic chambers for variety of insect species. This diversity is also supported by overall world axis orientation, as the species have different preferences to i.e. sun and wind exposure. The inner structure of the chambers towards the tree trunk is open to secure escape in all kinds of situations without climatic exchange (see Figure 11). The wood itself allows future algae and lichen habitat to support its responsive feature while the pine wood material does not attract decaying species.

Figure 11: The Inner Structure of TreeHugger (Photo: Davidová 2017)

I.e. the Ray 2 responsive wood envelope prototype is in semi-dry April weather partly open for boundary exchange between exterior and semi-Interior (see Figure 10 left). After April light rain the system immediately closes, not allowing the humid and cold air to pass through the boundary (see Figure 10 right). Both photographs in the figure are taken in the same day after four years that the prototype has been exposed to weather and biotic conditions. The prototype is inhabited by blue stein fungi, algae and lichen. These, namely the algae, are regulating the moisture content of wood, thus co-causing its warping. Notice also the organisation of algae habitation caused by the material's fibre direction and position within the design that is affected by material performance and form. Thus it is organised through its moisture and the organism's abundance and distribution interaction (Davidová, 2017a).

This *'non-anthropocentric architecture'* (Hensel, 2013) is to support co-living and co-creation across the species and abiotic agents within urban environment. However, the first author claims that her evaluation of such crossed interaction is in the end also the most beneficial to humans (Davidová, 2016b). Anderson at al. points out the necessity of human public engagement in-, experience of- and participation in- such to appreciate it (Andersson, Tengö, McPhearson, & Kremer, 2015). We would be more specific and add that this cannot happen without its co-design, co-creation and co-living. While the, later on digitalized, analogue GIGA-mapping allowed for trans-disciplinarity and human public engagement, the Grasshopper parametric modelling allowed fast responses in design changes and environmental diversity of designed spaces. This is due its customisation of spatial organisation that have been co-generated through material performance life, in real life.

To avoid future design restrictions a new prototype of Ray panelling research lead by the first author was needed due to possible surface curvature. Ray 1, 2 and 3 (Davidová, 2013, 2016a) were designed to operate only on a flat surface. The use of parametric modelling tool Grasshopper enabled working on the structure of panelling even without knowing the exact shape. This way Ray 4 was developed.

3.2 The Eco-Systemic Prototypical Urban Intervention TreeHugger

The discussed prototype TreeHugger (see Figure 1) is an insect hotel prototype and application in public space in the same time. It serves both, as dwelling for insects and algae as well as, while following the concept of *'edible landscape'* (Creasy, 2004), providing urban farming of food for local bats and birds. Therefore, it is interacting with a local specific eco-systemic chain. While interacting with the system, it co-designs and re-designs the ecosystem. Therefore, the eco-systemic prototypical urban intervention can better the overall eco-systemic environment within the location. Flying insects in general by their bio-mass and birds from agricultural land decreased by 80% since 80ties/90ties in the Central European region (Czech Ornithologists Association, 2016; Vogel, 2017). Many of these have been observed to adapt to the urban environment, being safer than agricultural land full of herbicides, pests, etc. This project is to re-design the urban environment to adapt to the new coming neighbours for the co-living situation with humans. It took part in larger eco-socio interventionist project COLridor (Davidová, 2017) that culminated through multi-genre EnviroCity festival (Davidová & Kernová, 2016), organized for the reason of human community engagement. One of the critical part of attracting it is also aesthetics (see Figure 1). This also proved to perform against vandalism from variety of social-groups in this and our previous public space interventions (Davidová, Šichman, & Gsandtner, 2013). The larger scale context of COLridor and EnviroCity is discussed in separate paper 'COLridor: Co-Design and Co-Living for Sustainable Futures' (Davidová & Zímová, 2017).

With local specific adjustments options, we intervened globally, publishing the production code and information for non-commercial Creative Commons usage (Creative Commons, 2017). The crucial part is that the reproductors will correctly differentiate on left and right side of the panels in reference to the position in the tree trunk, therefore the fibre density, for the direction of warping. With the common accessibility to the laser cutting machines and basic workshop tools in the cities, the communities can adopt and adapt such interventions in their public spaces. Therefore, the eco-systemic urban intervention can also be performed as DIY *'Service Design'* (Stickdorn & Schneider, 2011), possibly with larger impact after the first prototype was born and observed.

4 Conclusions and Speculations

The project has developed the concept of responsive wood into its first dwelling and urban farming application with the advanced use of its material features and the prototype has welcomed its first inhabitants at the end of the season. Its larger eco-systemic impact is subject to larger observations. However, even its current eco-systemic engagement is observable and unquestionable. Though we are not claiming any *'butterfly effect'* (Stewart, 2002), we claim the re-design of the system through interacting with it. We therefore claim that its crucial co-design process is the process of its performance within its real life physical environment, interacting with overall adjacent biotic and abiotic eco-systemic agency. The work on the prototype and the prototype itself also managed to generate public curiosity, interest and engagement in local bio-top support. There also its attractive outfit design plays crucial role. Please, see Figure 1 where it is catching the eyes of passers-by.

However, we cannot neglect the role of media and agency mix also in GIGA-Mapping within its design process with which the Grasshopper coding worked well in feedback looping in co-designing the public and transdisciplinary communication and co-design itself. The parametric features of the model allow for adjustments to specific variations for any other future applications. However, from our experience, we have never digitally fabricated anything, that would fully fit into real life physical environment. It is therefore wise, to keep several aspects open for real time improvisation and real life problematique adaptation when prototyping the 'result'. Therefore, we claim, that analogue and digital processes need to be combined and benefit from each other in all kinds of designing, analysing and design goals.

With basic understanding of wood material science and coding, the prototype can be rebuild by other communities, when digitally, materially, structurally and, first of all, nature-culture-socio-geography specific adjusted to co-create itself on place in real time. Though the code for the TreeHugger was given under Creative Commons Attribution-NonCommercial 4.0 International (CC BY-NC 4.0) Licence (Creative Commons, 2017) to tinkering public before X-Mass for free at project's Facebook site. We urge, that all the prescript fabrication always require on site creative designers' and the environments' themselves analogue real life environmental adaptation.

Therefore, the project that is inspired by concept of *'ecological urbanism'* (Mostafavi & Doherty, 2016a, 2016b) is twofold. It is in one-way physically prototyping and testing our work through overall eco-systemic engagement. On the other hand, it is giving the tool to communities to spread the work through using the parametric code for local specific prototyping. These multi-layered and multi-scaled local specific eco-systemic co-design real time processes are therefore building the ground of the very open newly emerging design field of **Systemic Approach to Architectural Performance**.

Credits:

The project is co-organized by Collaborative Collective, z.s., CooLAND, z.s. with support of the Technical University of Liberec, Faculty of Art and Architecture and the Faculty of Forestry and Wood Sciences at the Czech University of Life Sciences in Prague and co-designed with them respectively, together with the local community and local environment. It has been, by now, co-funded by VIA Foundation and through EEA Grant program for Biodiversity and Climate Change Adaptation lead in cooperation of the Technical University of Liberec, Faculty of Art and Architecture and the Oslo School of Architecture and Design. The sponsorship involved the Forests of The Czech Republic, Stora Enso, Rothoblaas, Škuta Design and the Faculty of Forestry and Wood Sciences at the Czech University of Life Sciences in Prague.

The festival events were listed as a part of European Sustainable Development Week and European Cultural Heritage Days.

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