

# **Wood as a Primary Medium to Eco-Systemic Performance: A Case Study in Systemic Approach to Architectural Performance**

**Doctoral Thesis Booklet by Marie Davidová, MArch.**

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I, Marie Davidová, hereby confirm that the work in the thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated.

The present research considers **wood** as a study material for a wider question on architecture's environmental<sup>1</sup> interaction. It aims to explore its potential for **eco-systemic<sup>2</sup> performances<sup>3</sup>** and **atmospheres<sup>4</sup>** as well as to broaden the discussion on this problem area by accessing the **public space** and **professional practice** calls. My project researches such interactions through practical experiments as well as theoretical reflections, including examinations of other scientific, design, artistic and crafts disciplines. It honestly discusses the successes as well as the failures and weak points to develop a strong background for **eco-systemic collaborative design-research practice**.

The methodology **Research by Design<sup>5</sup>** while **full scale prototyping** is covered by the **Systems Oriented Design<sup>6</sup>** to interpret and develop complex environmental relations. While doing so, this work also claims develop the **methodology** itself and to **generate theory through experimental practice**. The fusion of these **process based** fields led to the ratification of new design field: **Systemic Approach to Architectural Performance<sup>7</sup>**.

The dissertation is an **article based thesis<sup>8</sup>**, where the texts of the articles have been shortened of the

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<sup>1</sup> 'Environment is physical and biological surroundings of an organism. The environment covers non-living (abiotic) factors such as temperature, soil, atmosphere and radiation, and also living (biotic) organisms such as plants, microorganisms and animals.' (Oxford University Press, 2004)

<sup>2</sup> Ecosystem was described by Allen and Roberts as an ecological system inside the system that includes the geophysical part. (T. F. H. Allen & Roberts, 1993)

<sup>3</sup> Leatherbarrow is explaining the performance view on construction: '...when the preparations of well-designed construction are seen to be inevitably inadequate, when the finished work is understood to be necessarily incomplete, because the world of which it is part is recognized as a field of forces that will, over time and unpredictably, re-qualify what design and construction had pre-qualified.' (Leatherbarrow, 2013)

<sup>4</sup> 'Quality in architecture . . . is to me when a building manages to move me. What on earth is it that moves me? How can I get it into my own work? . . . How do people design things with such a beautiful, natural presence, things that move me every single time. One word for it is Atmosphere.' (Zumthor, 2006a)

<sup>5</sup> 'Research by Design is any kind of inquiry in which design is a substantial part of the research process. In research by design, the architectural design process forms a pathway through which new insights, knowledge, practices or products come into being. Research by design generates critical inquiry through design work that may include realized projects, proposals, possible realities or alternatives. Research by design produces forms of output and discourse proper to disciplinary practice, verbal and non-verbal that make it discussable, accessible and useful to peers and others. Research by design is validated through peer review by panels of experts who collectively cover the range of disciplinary competencies addressed by the work.' (ResEAAErch, 2017)

<sup>6</sup> Systems Oriented Design: 'an approach to learn how to better cope with very complex issues as designers. The approach is influenced and inspired by modern systems thinking and systems practice and inspired by generative diagramming. Design practice, systems thinking, systems practice, design thinking, information visualisation, diagramming, GIGA-mapping, research by design, research through design, design for complexity, sustainability.' (Sevaldson, 2013b)

<sup>7</sup> The notion of Systemic Approach to Architectural Performance was first expressed by me in 2016 as a title for collaborative project among me, Birger Sevaldson, Michael Hensel and Miloš Florián that was fusing Performance Oriented Architecture and Systems Oriented Design. This project was supported by EEA and Norway Grants as a bilateral partnership program between the Faculty of Art and Architecture at the Technical University of Liberec and the Oslo School of Architecture and Design (Davidová, 2016h, 2016i). The project's continuation among the same design - researchers participants for the bilateral partnership between the CTU in Prague and the Oslo School of Architecture and Design has been recently submitted for funding to the same donor.

<sup>8</sup> *PhD Thesis Requirements at CTU in Prague*: '1. A dissertation is the result of solving a particular scientific or artistic task; PhD student demonstrates the ability to work independently in a creative way and it must contain original authorship of the dissertation published results of scientific or artistic work or results accepted for publication; 2. A general theme or themes of dissertation are offered during the admissions procedure on the basis of the future supervisor, followed by the recommendation of the head of the training department and the consent of the Scientific Committee. A more specific definition of the topic within the thematic area is possible upon an agreement between the supervisor and the candidate; 3. The title of the dissertation, including its load is set at the latest at the end of the study unit on the basis of the submitted studies and debates on the topic of dissertation under – see Art. 27 paragraph. 7<sup>th</sup>; 4. The dissertation can be recognized and accepted as a set of publications or manuscripts joint by an integrating text; 5. dissertation is written in Czech, Slovak or English. Applicants may, with the agreement of the President of the Scientific Committee, submit a dissertation in one of the other world languages. Other formal requirements for dissertation is specified by the dean of the faculty. If the work does not meet these formal requirements it may be not accepted by department for science and research for further proceedings. In case of doubt the decision is concluded by the Dean. (Konvalinka, 2015)

>> *PhD Thesis Requirements at FA CTU in Prague*: 'Formal and Content of State doctoral examinations, dissertation and its defence is specified in

parts mentioned elsewhere in the work and underwent through language check. These serve as an addendum covered with an exegesis. Most of the repeating images were removed from the articles. If there is an exception this is reasoned through its important relation to the present text.

All substantial contributions are mentioned within the text and/or summarized in the Thanks chapter of the thesis. To mention the main **institutions** and **practice/NGO's** respectively, this **research has been collaboratively developed** at the Faculty of Architecture at the Czech Technical University in Prague, the 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, the Academy of Art, Architecture and Design in Prague, the Architectural Institute Prague, the Oslo School of Architecture and Design, the University of Chemistry and Technology in Prague, the Faculty of Civil Engineering the Czech Technical University in Prague, Collaborative Collective, Defio, Oximoron, re.code.nature, CoolLAND, Experis SDKM and reSITE.

The work is a second, **revised edition** of the thesis, when the first, work in progress, publication called ***Wood as a Primary Medium to Architectural Performance: A Case Study in Performance Oriented Architecture Approached through Systems Oriented Design*** (Davidová, 2016j) served as a **tool to receive broader feedback** from its readers. The first publication was kindly supported by **EEA and Norway Grants** through the project **Systemic Approach to Architectural Performance**, was printed on paper with 100% of recycled fibre. This edition was **reviewed by a gender equal team** and is to be defended in front of a **gender equal selection of opponents**. The work itself is dedicated to our **Biosphere**<sup>9</sup>.

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the requirements and recommendations for additional SER CTU.' (Lábus, 2016)

>> *Additional PhD Thesis Requirements and Recommendations by SER CTU:* 'Also dissertation as a set of publications or accepted manuscripts joined by integrating text can be recognized. Dissertation is written in Czech, Slovak or English language... ..Dissertation has the following formalities and obligatorily includes: 1. The cover or first page: marking the university, the faculty and supervising department, dissertation title, 'Doctoral Thesis' title, name of the PhD candidate, the year of submission, supervisor's name, study program, field of study; 2. In the introductory part: target of the dissertation and an overview of the current state of the science issues (with references to literature); 3. In the final part: overview of results, including the original dissertation doctoral student contribution (i.e. a brief overview of the results of dissertation and how to improve the current situation), the conclusions for future the advancement of science or for implementation in practice; 4. One-page abstract in English.' (Fialová, 2016)

<sup>9</sup> Biosphere is 'irregularly shaped envelope of the earth's air, water, and land encompassing the heights and depths at which living things exist. The biosphere is a closed and self-regulating system (see ecology), sustained by grand-scale cycles of energy and of materials—in particular, carbon, oxygen, nitrogen, certain minerals, and water. The fundamental recycling processes are photosynthesis, respiration, and the fixing of nitrogen by certain bacteria. Disruption of basic ecological activities in the biosphere can result from pollution.' (Lagasse & Columbia University, 2016)

## Annotation in Czech:

V době, kdy přírodních zdrojů stále ubývá, se obrací pozornost k obnovitelným materiálům a jejich efektivnímu využití při co nejmenší spotřebě energie. K takovýmto materiálům patří ve stavebnictví především dřevo. Předložený výzkumný projekt chápe **dřevo** jako studijní materiál pro obsáhlejší otázku interakce prostředí a materiálu v architektuře. Usiluje o prozkoumání tohoto potenciálu pro **ekosystemické performance** a **atmosféry** a o rozšíření diskuse v této problematice. Můj projekt zkoumá tyto interakce skrze praktické experimenty a teoretické reflexe, což zahrnuje ostatní vědecké disciplíny, umění a řemeslo, k vytvoření silného základu pro **ekosystemickou, kolaborativní návrhově-výzkumnou praxi**.

Projekt je případová studie v oboru **Performance Oriented Architecture** za použití metodologie **Systems Oriented Design** a **Research by Design** při **prototypování v plném měřítku**. Performance Oriented Architecture je udržitelná architektura, která interaguje se svým prostředím. Toho je převážně dosaženo na základě vlastností materiálu nebo materiálových systému pro získání tepelné či sociální pohody, či k podpoře daného ekosystému. Systems Oriented Design je metodologie kloubící systémové myšlení s designem v návrhacích a analytických procesech. Jeho nejdůležitějším nástrojem je **GIGA-mapping**, vizuální diagramování komplexních mezioborových vztahů. Této metodologie se používá zejména u projektů typu Research by Design, spojujících akademii s praxí, kde jako důležitá podpora výzkumu slouží prototypování. Výzkum samotný tyto metodologie rozvíjí a tvrdí, že generuje teorii skrze praxi. Fúzí těchto přístupů založených na procesu vzniklo nové pole designu: **Systemický přístup k architektonické performanci (Systemic Approach to Architectural Performance)**.

Dřevo má díky svému biologickému založení specifické vlastnosti. Mezi ně patří především interakce materiálu s vlhkostí a teplotou. Dřevo se **bortí**, roztahuje a stahuje v závislosti na **relativní vlhkosti vzduchu** a **teplotě**. Tato vlastnost se dá využít organizací jednotlivých dílců do systémů, které na takové podněty reagují k našemu užitku. Systémy proto ke svému ovládní užívají **primární energii**, bez nároků na elektřinu. Svou performancí pak regulují **mikroklimata semi-interiérových prostorů a exteriérů**. V roce 2015 vydalo Ministerstvo životního prostředí ČR Strategii přizpůsobení se změně klimatu v podmínkách ČR, kde se kromě nutnosti snížení energetické náročnosti budov také diskutuje o **nárůstu klimatických extrémů**. **Vytváření životu příznivých mikro-klimat je jedním z cílů adaptace našich měst**. V disertační práci jsou shrnuty poznatky sledované na systémech z masivního dřeva v interakci s relativní vlhkostí vzduchu a teplotou. Jedná se především o stěny **Ray 2 a 3**, které větrají za sucha a uzavírají se za vlhkého počasí na základě svých materiálových vlastností, tedy bez využití elektrické energie. Dále pak byly zkoumány prototypy **dvou pavilonů**, jakožto komplexnější environmentální analýza, kde byla sledována tato interakce globálněji, z hlediska orientace ke světovým stranám (Figure 1). Projekt zahrnuje i nastínění reálné aplikace v architektuře na příkladu **dvou architektonických soutěžních návrhů** (Figure 24 a Figure 31).

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## 2. Thanks

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This project would have never happened without the kind support of Collaborative Collective, EEA and Norway Grants, Faculty of Forestry and Wood Sciences at Czech University of Life Sciences, ARCHIP, Faculty of Art and Architecture at Technical University of Liberec, Faculty of Architecture at Czech Technical University in Prague, Academy of Art, Architecture and Design in Prague, re.code.nature, Oximoron, Defio, s.r.o., AZ-TECH, s.r.o., Prague Institute of Planning and Development, Landscape festival Praha 2014, Nákladové nádraží Žižkov, Experis SDKM, CoolAND, SKANSKA, Stora Enso, Rothoblaas, Eurodach, Natura Dekor, Náradí Bartoš, Lesy ČR, P-Print, Škuta Design, Empeureum Information Technologies, reSITE, Meloun Production, Easy Moving, Nadace Život umělce, Nadace Proměny, Paperlinx, Vinařství Sonberg, Městská část Praha 3, Nová síť, o. s., Nadace Proměny, Auto\*Mat, Lunchmeat, TANEC PRAHA, Uličník, Rekola, I Need Coffee, Architekti ve škole and Matério to whom belongs my great thanks.

### 3. Introduction



Figure 1: Research Prototypes that Are Moderating its Micro-Climatic Ambient Environments through Material-Environment Interaction Causing Sorption or Evaporation followed by Warping, from the left to right a) pereSITE Pavilion during the Public Lecture and Discussion on the Design-Research at reSITE Festival (photo: Pedersen 2013); b) Loop Pavilion Tested by My Self for Its Opportunistic Use – Posing at the Press Conference before the EnviroCity's Festival Release (photo: Exner 2014, from Exner, 2014, with the courtesy of City Council of Prague); c) Ray 2 Prototype in Sunny Summer Weather after Three Years of Being Exposed to Highly Biotic and Abiotic Conditions next to a Forest Hillside for its Environmental Interaction – notice algae distribution along the grain of the panels (photo: Davidová 2016); d) Ray 3 Prototype Getting into its Narrow State during an Increase of Relative Humidity, thus Sorption of the Material (photo: Davidová 2016)

This research by design<sup>10</sup> is seeking answers to the question of what is a solid pine wood's environmental interaction and how it can be used in **Performance Oriented Architecture**<sup>11</sup> applied in **Czech locations**. This is looked upon from **Systems Oriented Design**<sup>12</sup> perspective. By integrating these fields from **eco-systemic perspective**, the work leads to the ratification of a new design field: **Systemic Approach to Architectural Performance**. Therefore, the case study demanded larger complexity of investigation as one cannot divide the field into fragments. This is obvious when it comes to discussion on eco-systems. Ulanowicz describes that '*ecosystems*'<sup>13</sup> behave in ways that are very different from the systems described by other sciences, i.e. evolutionary theory, ethology, mechanics, thermodynamics, etc. And that the ability of aggregated mechanical constructs, otherwise known as '*eco-systems models*', to predict the behaviour of ensemble eco-systems is notoriously poor. (Ulanowicz, 1999). Therefore, he also discusses '*Ecosystems Phenomenology*'<sup>14</sup> (Ulanowicz, 1988). The importance of performance of the whole is also discussed by Gestalt Psychology (Wertheimer, Koffka, Köhler and others)<sup>15</sup>. With the understanding of above mentioned, several full scale prototypes, their production and application in architectural and '*urban design*'<sup>16</sup> and eco-systems, design processes and the methodology itself were all interpreted through practice as fused ever evolving biotic as well as abiotic co-

<sup>10</sup> For the reason, that the work is '*research by design*' authored or co-authored by me from the position of project leader, there is a large auto-referencing appearance. This necessity is also supported by the fact, that there is no similar research in the location. As the work is local-specific and there is no other author in the field and location, auto-referencing was unavoidable.

<sup>11</sup> 'Performance-oriented Architecture, a subset of Performance-oriented Design, that engages the key concepts 'non-discrete architectures' and 'non-anthropocentric architectures'. The former seeks for a higher level intergration of architecture and environment that are locally specific and intensely embedded in their setting. The latter aims for an integration of ecology and urban ecology considerations on the scale of architecture.' (Hensel, 2015)

<sup>12</sup> Systems Oriented Design: 'The designerly way to work with systems: The main mission of Systems Oriented Design is to build the designers own interpretation and implementation of systems thinking so that systems thinking can fully benefit from design thinking and practice and so that design thinking and practice can fully benefit from systems thinking.' (Sevaldson, 2013a)

<sup>13</sup> 'By ecosystem we mean a view that explicitly includes the geophysical part of an ecological system inside the system.' (T. F. H. Allen & Roberts, 1993)

<sup>14</sup> Ecosystems Phenomenology is contrasting analytical processes that are dissecting that which is whole, probing that which is small, and looking for causes in component parts (Ulanowicz, 1988).

<sup>15</sup> Wertheimer, Koffka, Köhler did not claim that the whole is more than the sum of its parts but that objects and relations are experienced differently than collection of sensations, parts or pieces (Ash, 1998).

<sup>16</sup> 'Urban design is about making connections between people and places, movement and urban form, nature and the built fabric. Urban design draws together the many strands of place-making, environmental stewardship, social equity and economic viability into the creation of places with distinct beauty and identity.' (UrbanDesign.org, 2017)



design, being the design-research process and the result in the same time.

This **multiple approach** to generate **rich thesis** is reasoned from observations of a reductionist's architectural design applications, that were also criticised i.e. by Hemmersam and Morrison<sup>17</sup> in relation to local specificity (Hemmersam & Morrison, 2016), the core of this thesis. In the last few decades, a large amount of computer generated designs inspired by material, biological or social systems i.e. have been built. These attempts often failed to engage the main field of their inspirations, the material, the biological and the social systems themselves in real life, thus not achieving any real life performance. For this reason, and because there is not enough research in related areas, the research had to investigate and bring more multi-layered acquisitions to the fields. Architectural and Urban Design are being commonly understood as the most complex disciplines – so must be the research by design in these disciplines. Therefore, to conclude with acquisitions to only three major fields seems to be reduced to a minimum. These cover:

a) **the methodology:** MINI-maps, Processing Performance of the Whole, Performance of the Whole, Rich Design Research Public Space, Feedback Looping of Final Prototypes, Time Based Eco-Systemic Co-Design, Practice Generated Theory (see Methodology Research Acquisitions section);

b) **the material research:** Life Cycle Based Eco-Systemic Material Selection, Force-Hygroscopicity Relations, Time-Based Force-Hygroscopicity Relations, Angle Cut-Fibre Direction Hygroscopicity Performance, Sugar and Amyl Free, Biological De-Re-Sorption Relation, MC-Cut Hygroscopicity Relation, Material-Design Life Cycle, Introduction of Solid Wood Responsivity to POA (see Material Research Acquisitions section);

c) **architectural and urban design field:** Responsive Solid Wood's Application, Performance Based Beauty – Beauty's Performance, Embodied Architectural Performance, Boundary Conditions Crossing, Onion Principle, Eco-Systemic Environmental Interaction Principle, Trans-Co-Design, Local Climatic Adaptation (see Architectural and Urban Design Research Acquisitions section).

Inspired by the performance of traditional architecture from locations with more extreme climate histories, this case study mainly focuses on performative potentials of solid pine wood cut in tangential section; to be precise – its cup warping – and particularly how this might be applicable in the specific climatic conditions of Czechia. With today's climatic change in our region, there is a necessity to search for the adaptation of our local architecture in different places where such conditions have been already present.

## 4. Placement of My Research in Reference to Performance Oriented Design and Systems Oriented Design

This research is a case study in a broad area of **Performance Oriented Architecture** (Hensel, 2010, 2011, 2012e, 2013), as a subfield of **Performance Oriented Design** (Hensel, 2015) ratified and commenced in 2008 (Hensel & Sunguroğlu Hensel, 2013), focusing mainly on material-climatic-biotic performance and its sustainable application in architectural and urban design practice in the researched location. Though the history has a larger background (Hensel, 2013), the shift to performance in architecture in the context discussed in this thesis explicitly appeared in 2001, when Stan Allen reformulated the question of what is architecture to what architecture can actually do (S. Allen, 2011). This work is approached as a **'figuration of fields of relationships'** (Hensel & Menges, 2009). Therefore Systems Oriented Design, a **'designerly way to work with systems'** (Sevaldson, 2013a) and **'Research by Design through full-scale prototyping'** (Davidová & Sevaldson, 2016a; Hensel, 2013; Sheil, 2008) and **prototypes observations** appeared to be the most suitable methodologies for such. To reach these processes that are generating research through collaborative transdisciplinary projective practice, the project had to glue Academy, Practice and

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<sup>17</sup> Hemmersam and Morrison reject the modernist 'result of abstract utopian ideas' and propose 'moving beyond the reductivism' through 'methodology involving transect walks, with the purpose of mapping the peculiarities of cultural landscapes.... [this] includes the ephemeral and emergent, but also digital, dimensions of urban landscapes, and results in a complex reflexive method of critically reading and writing, of moving and locating, of seeing and picturing place mapping.' (Hemmersam & Morrison, 2016) This work is addressed to Arctic climatic location. Therefore, it is very relevant for this thesis, as it is discussing the expected weather extremes in discussed location in reference to its adaptation.

NGO in cooperation with industry through Research by Design (Davidová & Sevaldson, 2016b). The research also covered hard data measurements of micro-climatic conditions in relation to moisture content of the wood and its placement, but this data is not elaborated in detail within the thesis because it is not its focus. It only served as a generative input for the design development. The thesis is focused on practise and therefore covers a **wide and rich spectre of issues** while aiming towards **durable application and sustainability in many interpretations**. This mission is theoretically supported i.e. by paper: Sustainability from a Performance-Oriented Architecture Perspective – Alternative Approaches to Questions regarding the Sustainability of the Built Environment<sup>18</sup>, proposing **holistic systems approach** (Hensel, 2012e).

## 5. Placement of My Research into State of Art in Reference to Material, Types of Prototypes and Location

This chapter covers the **key concepts** within the state of art in the fields of this thesis, and positions my own research within the field. It also describes the selection of the material through **Life Cycle Assessment (LCA)**<sup>19</sup> **comparison** of solid wood and plywood applied on my prototype Ray 2 for the **location of Czechia**. The selection of discussed projects is covering prototypes that have substantive contributions in the **responsive wood** field in the context of material research or the type of prototype application in relation to the environment or both.

The contemporary research on **performative/responsive wood** is mainly spearheaded by Michael Hensel and Defne Sunguroglu Hensel at the Research Centre for Architecture and Tectonics (Hensel, 2012a; Hensel & Sørensen, 2016) Oslo School of Architecture and Design (Oslo School of Architecture and Design, 2016) and by Achim Menges, Steffen Reichert, Dylan Woods and others at ICD University of Stuttgart (Menges, 2013).

The field generally suffers from a lack of enough clear or deep information that has been published. While many examples can be found, explanation and/or significance towards the material research, dates and contributions of diverse people and institutions involved are published insufficiently. In some cases, the memory of the authors, audience or even personal observations had to be used.

## 6. Methodology: Systems Oriented Design and Research by Design while 1:1 Prototyping

In this chapter, the methodology of the research that was also **explored within itself** is explained. It covers **transdisciplinary co-working**, **full scale prototyping** and **employment of different organisational structures** within **Research by Design**, all utilised in **Systems Oriented Design**.

Systems Oriented Design was introduced by Birger Sevaldson in 2005 (Sevaldson & Ryan, 2014), is being developed by Birger Sevaldson, Michael Hensel and Defne Sunguroğlu Hensel (Sevaldson, 2013a) and others and is applied in Research by Design. It has its origin in design practice, design thinking and the complexity theory and systems thinking. Sevaldson argues that the changes in our globalized world and the need for sustainability demands an

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<sup>18</sup> 'This article introduces and discusses a series of alternative and interrelated concepts and approaches regarding questions of the sustainability of the built environment and architectural design. The need for this discussion arises from the realization that the majority of current approaches to questions of sustainability in architectural design tend to considerably stifle complexity in approach, problem analysis and definition. This development is characterized by isolated and partial aspects of environmental problems, instead of a more holistic systems approach, often present in the approaches of other disciplines or interdisciplinary efforts. The shortage of alternative approaches in architectural design requires a critical rethinking of the question of sustainability of the built environment and its relation to other domains in and outside the anthroposphere. To address this problem is the goal of this article. In doing so, it introduces and discusses concepts and approaches that are rooted in a systems approach and aims for more complex problem definitions, while taking longer-term perspectives into consideration. This is done from a performance-oriented architecture perspective, which operates on the dynamic interactions between local ecosystems (including humans), environment and the spatial? material organization complex of architecture.' (Hensel, 2012f)

<sup>19</sup> LCA is a complex evaluation of environmental impact of a product throughout its life cycle – from seeding a tree, through the pollution produced by its harvest, material processing, product application, its recycling and so on.

increase of the complexity of the design process (Sevaldson, 2013a). A base of Research by Design in Systems Oriented Design is the concept of Rich Design Research Space. It covers physical, social and digital space in which different actors play their role. Sevaldson shows that the design investigations are combined with cycles of observation, registration, and reflection within the research-design process (Sevaldson, 2008).

In my case, the **'Social Design Research Space'** is represented by trans- and inter-disciplinary networking of i.e., architects, coders, wood scientists, carpenters, the building industry, environment designers, structural engineers, ecologists, dendrologists, algologists, climatologists, artists and art and architectural theoreticians, culturologists, stage designers, dancers, musicians and actors-some individual, some related to different organisations and general public. The network was and still is growing based on the needs of the project and opportunities. The design is informed by transdisciplinary knowledge and skills, my personal measures of the samples, the prototypes and the biotic and abiotic environmental relations to it, simulations combined with the measured data, all discussed through personal experiences. The process is based on visualisations of such complex transdisciplinary relations via GIGA-mapping (see Figure 2). **GIGA mapping** is an extended visual diagramming of related knowledge that covers the design process. Sevaldson describes it as follows:

*'GIGA-mapping is super extensive mapping across multiple layers and scales, investigating relations between seemingly separated categories and so implementing boundary critique to the conception and framing of systems... GIGA-mapping is creating an 'information cloud' from which the designer can derive innovative solutions. While mapping in general is a way of ordering and simplifying issues, so to say 'tame' the problems, GIGA-mapping intends not to tame any problems. GIGA-maps try to grasp, embrace and mirror the complexity and wickedness of real life problems. Hence they are not resolved logically nor is the designerly urge for order and resolved logic allowed to take over too much and hence bias the interpretation of reality.'* (Sevaldson, 2011)

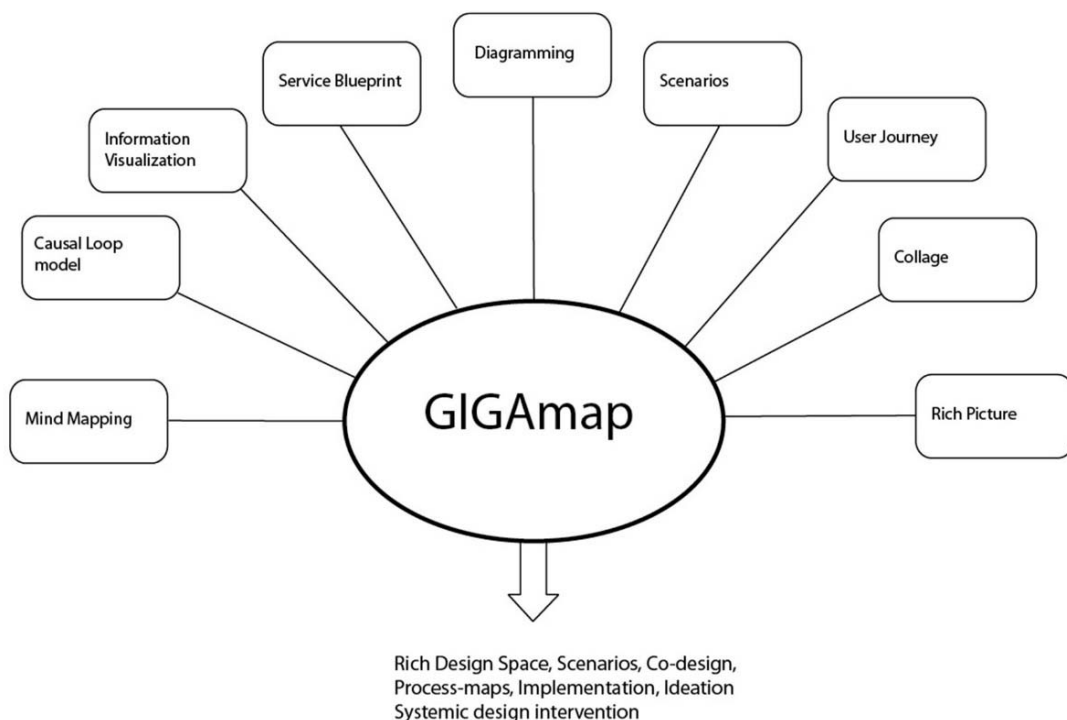


Figure 2: GIGA-map Map (Sevaldson 2014 – with the courtesy of Sevaldson)

From my observation, it is good to start with creating a GIGA-map straight during the literature study and updating it within the process. A GIGA-map certainly helps in leading the design phase in developing a complex product next to the simulation techniques, which in my case were mostly generated in Grasshopper for Rhino 5 based on the registration of the behaviour of the samples. Following a Systems Oriented Design process through GIGA-mapping led directly to different complexity full scale prototypes, research conclusions, questions, discussions and speculations on further development.

My working paper 'Generating the Design Process with GIGA-map: The Development of the Loop Pavilion' explains how GIGA-mapping (see Figure 3 and Figure 4) and online tools can be used in teamwork while designing and prototyping the Loop Pavilion and cooperating on the project in different locations. The paper introduces **MINI-maps** (see Figure 5) for fast concept sketching and physical GIGA-maps that can be reorganized during the overall process by using printed images, pins and threads (Davidová, 2014c).

The paper '1:1, A Transdisciplinary Prototyping Studio' co-authored with Birger Sevaldson explores the **necessity of full-scale prototyping** (see Figure 6) in comparison with the results obtained through samples observations and simulations and how the transdisciplinarity can be involved in such (Davidová & Sevaldson, 2016a). The discussion in the paper 'NGO, Practice and University Driven Research By Design on Performative Wood' co-authored with Birger Sevaldson opens the question, if the, by now only referred to, connection of research with practice in **Research by Design** is enough for experimental architecture. It is showing the example, how **NGO's**, practices and universities were joint within this project, arguing for better flexibility and potentials of such (see Figure 7). It is also opening the discussion of observations of material performance through interactions of performers' performance and opportunistic use inhabitation (see Figure 8 and Figure 9), that was clearly possible through NGO's involvement (Davidová & Sevaldson, 2016b). Such settings enabled **time-based co-design** within the research through EnviroCity Festival (Davidová & Kernová, 2016; Kernová, 2014). The recently resubmitted paper '**Systemic Approach to Architectural Performance: The Media Mix in Creative Design Process**' to Systemic Design III special issue of FORMakademisk is concluding the use of tools and actors involved within the design-research processes, arguing for the present necessity of development of project specific methods and proposing speculations for their further development. Instead of today mixing media, all interrelated in one **Physical Performative Environment GIGA-map** within **Rich Design Research Space**, being prototype and ever evolving result in the same time, is envisioned for the future (see Figure 8, Figure 9 and Figure 10).



Figure 3: LOOP Pavilion Design-Research Process GIGA-map as a Result of Transdisciplinary Studio Course<sup>20</sup> (administrator of the map and photo: Pokorný 2014) – For high resolution image see Systems Oriented Design web site (Sevaldson, 2016b) or RSD5 proceedings (Davidová, 2016c)

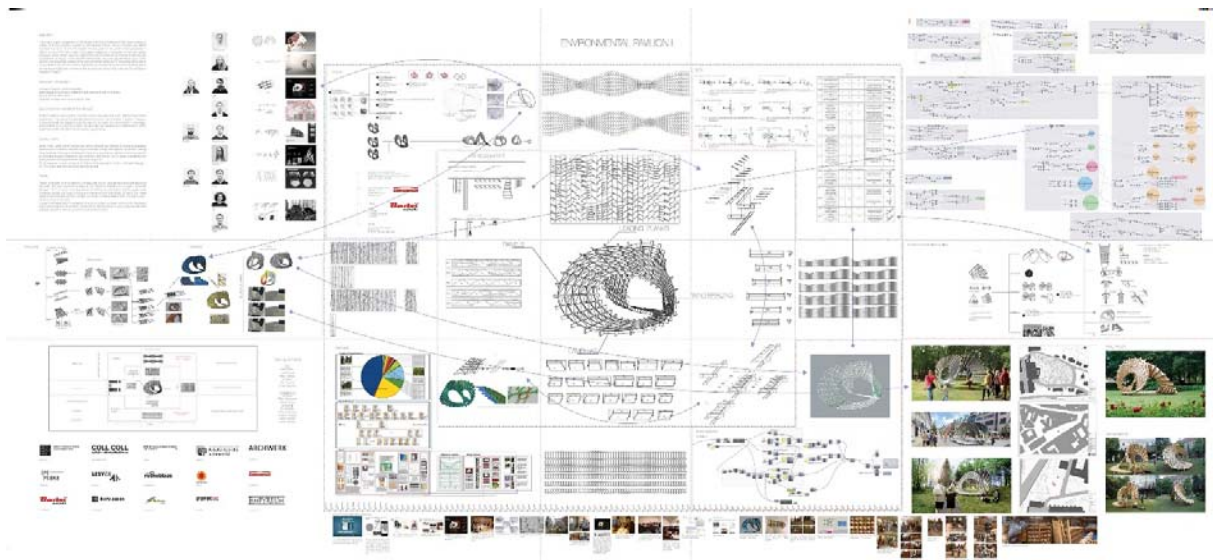


Figure 4: LOOP Pavilion GIGA-map as a Result of Transdisciplinary Studio Course (administrators of the map: Hrušová & Pokorný 2014) – For high resolution image see Systems Oriented Design web site (Sevaldson, 2016b) or RSD5 proceedings (Davidová, 2016f)

<sup>20</sup> Transdisciplinary Studio Course at the Faculty of Art and Architecture at the Technical University of Liberec and the Faculty of Forestry and Wood Sciences at the Czech University of Life Sciences in Prague: tutors: Marie Davidová, Šimon Prokop, Martin Kloda; students: Alena Novotná, Anna Hrušová, Antonín Hůla, Barbora Slavičková, Jakub Kopecký, Jiří Fáber, Jiří Pokorný, Petr Tůma, Tereza Jílková, Radim Sýkora, Eliška Antonyová, Tereza Lišková, Filip Janata, Tomáš Kytka, Marie Kortanová, Vojtěch Holeček, Martin Vaníček, Jakub Hlaváček and Petr Havelka 2014

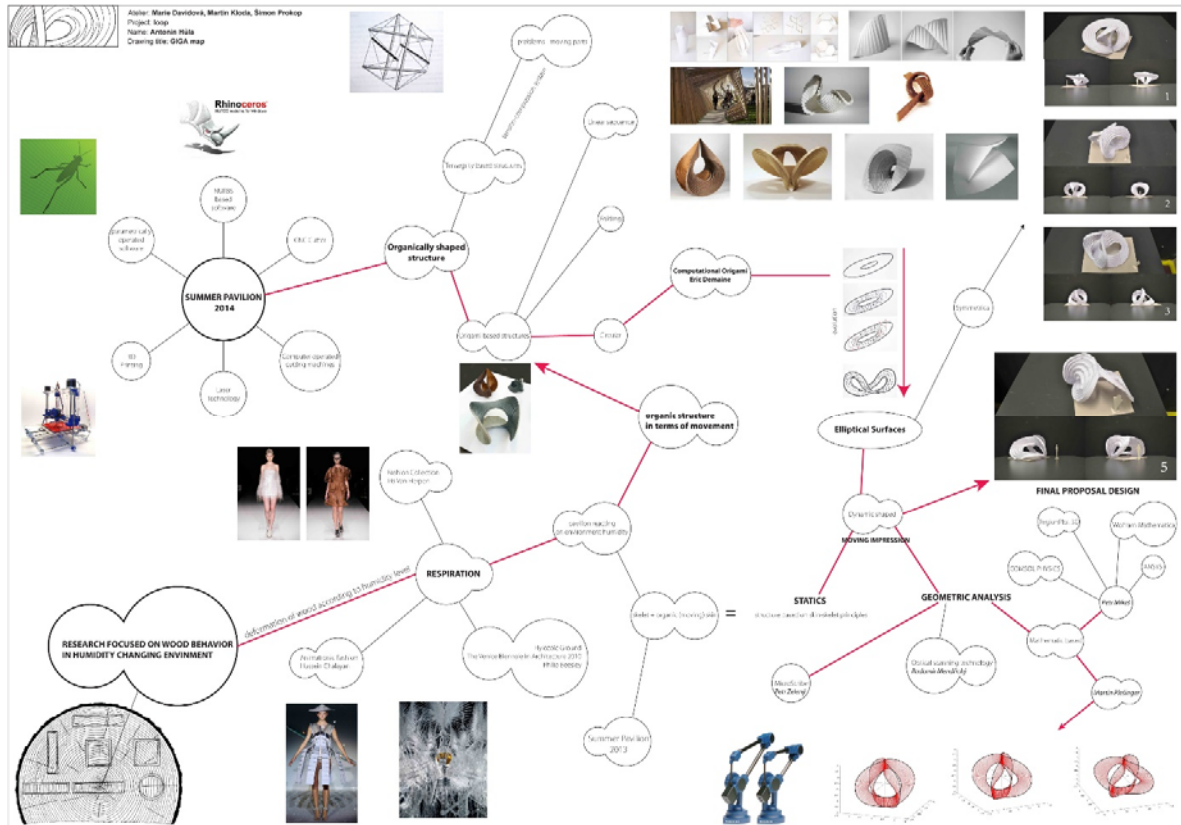


Figure 5: The winning Environmental Summer Pavilion II design LOOP MINI-map (Hůla 2014)



Figure 6: LOOP Pavilion Building (photo: Davidová 2014)

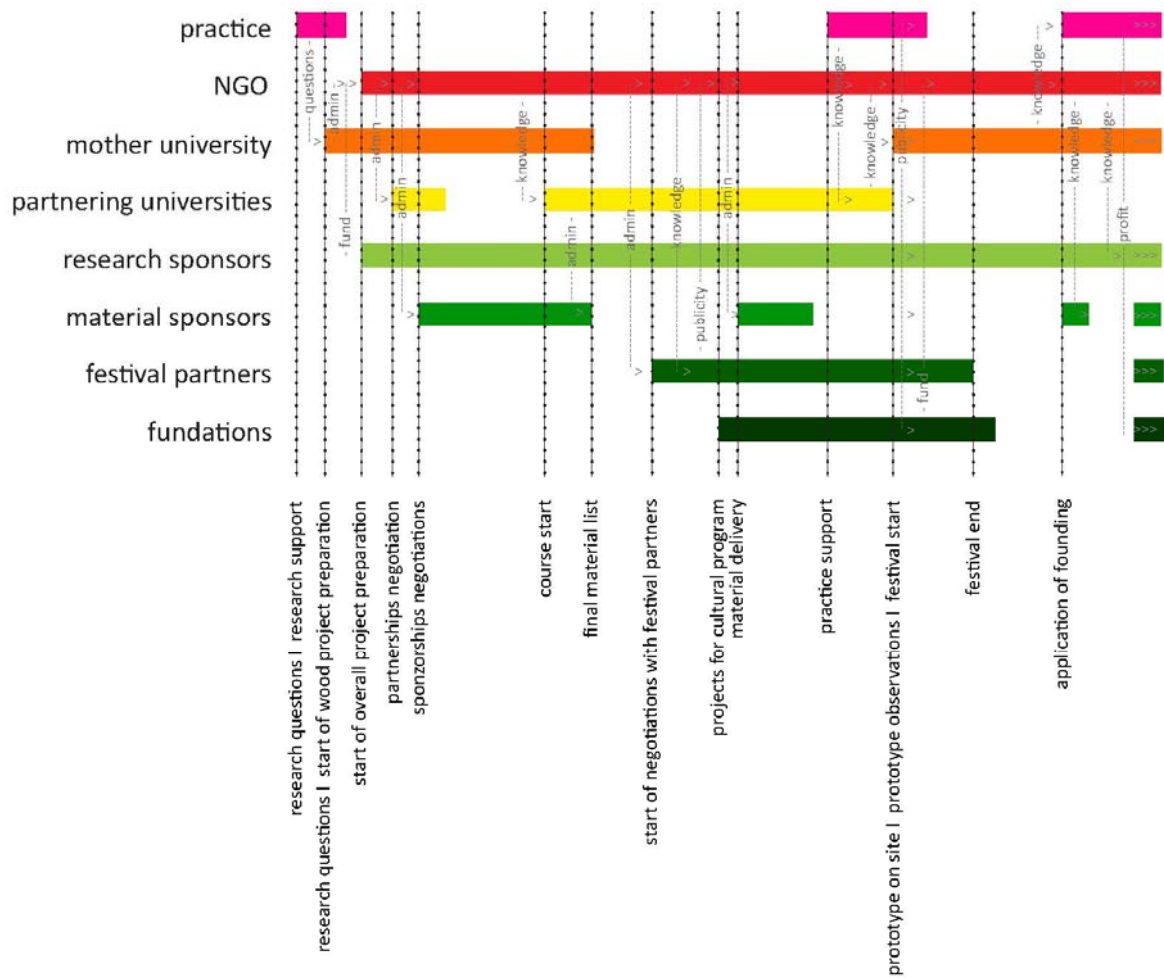


Figure 7: Action Diagram Mapping the Project Of LOOP Pavilion and its EnviroCity Festival (Graphics: Davidová 2015)



Figure 8: Pavilion's Embodiment by Dancer Kateřina Dietzová at EnviroCity Festival (photo: Novotná 2014)



Figure 9: Pavilion's Embodiment by Black Bird at EnviroCity Festival (photo: Škuta 2014)



Figure 10: Ray 2 Prototype Being in Time-Based Co-Design with its Micro-Climatic Conditions and Blue Stain Fungi, Algae and Lichen that Inhabit It, All Regulating the Moisture Content of Wood, Thus Causing Warping. Notice Also the Organisation of Algae Habitation Caused by Material's Fibre Direction and Thus Moisture Distribution (photo: Davidová 2016)



## 7. The Material in Relation to Environment

This chapter covers the discussion on material selection from its **eco-systemic, resource and material performative properties perspective**. Analysing the eco-systems of the **forests** of research's location (see Figure 11) and the **material's micro-climatic and biotic interactions** (see Figure 12, Figure 13, Figure 14, Figure 15 and Figure 16) in relation carpentry of it lead to extended number of interviewing, observations, sampling and registering. Data for such **design-research** were not available and if they were, they merely differed from of what was registered on samples or discussed with experienced craftsmen, wood material scientists or traditional open air museum's research and preservation staff, most likely for its simplification. It exemplifies the **'programativity disadvantages'** of the use of solid wood but also the in depth investigation to **its conclusion**. However, this topic is rather theoretically concluded in closing chapter of this thesis in relation to its **eco-systemic application**.

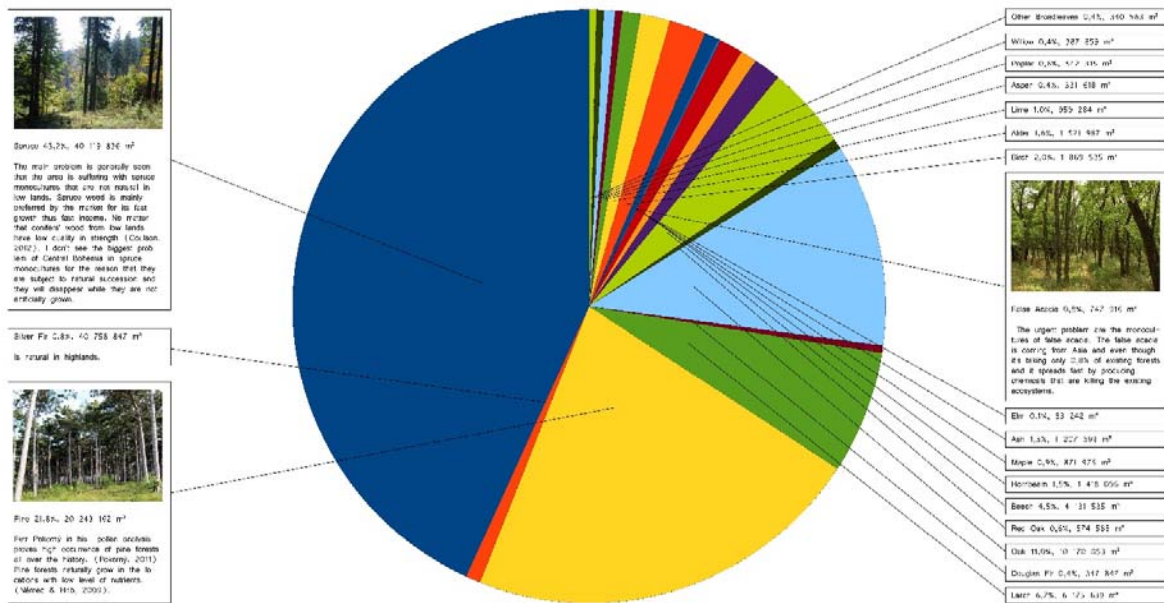


Figure 11: The Percentage of Tree Species in the Forests of Central Bohemia (diagrammed by Davidová 2013; data used from Forest Management Institute Brandýs nad Labem, 2012)

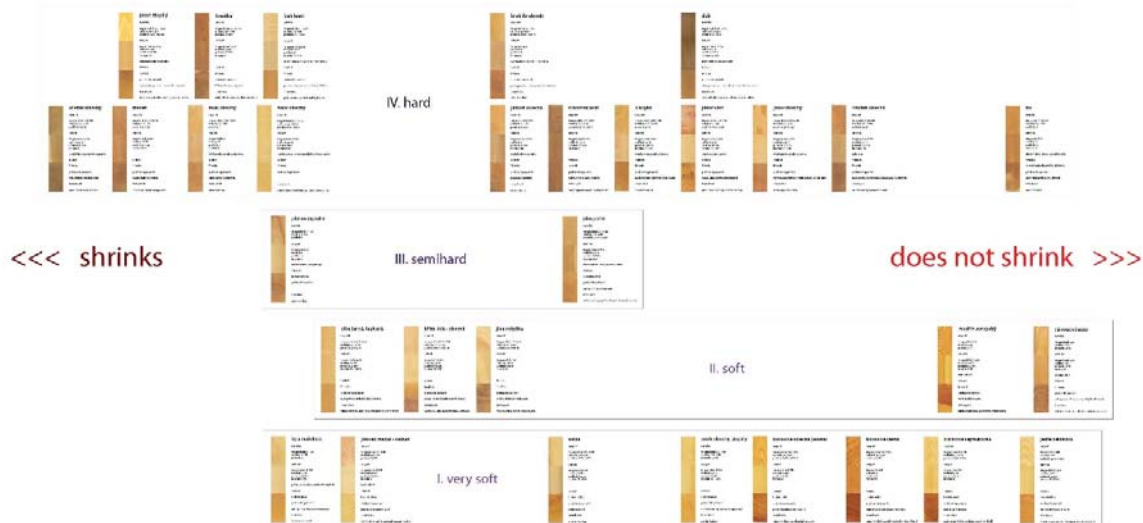


Figure 12: Davidová 2012: Map of Shrinking and Warping of Different Local Wood Species (data and most of the images from: Němec, 2005 used with the courtesy of Grada)

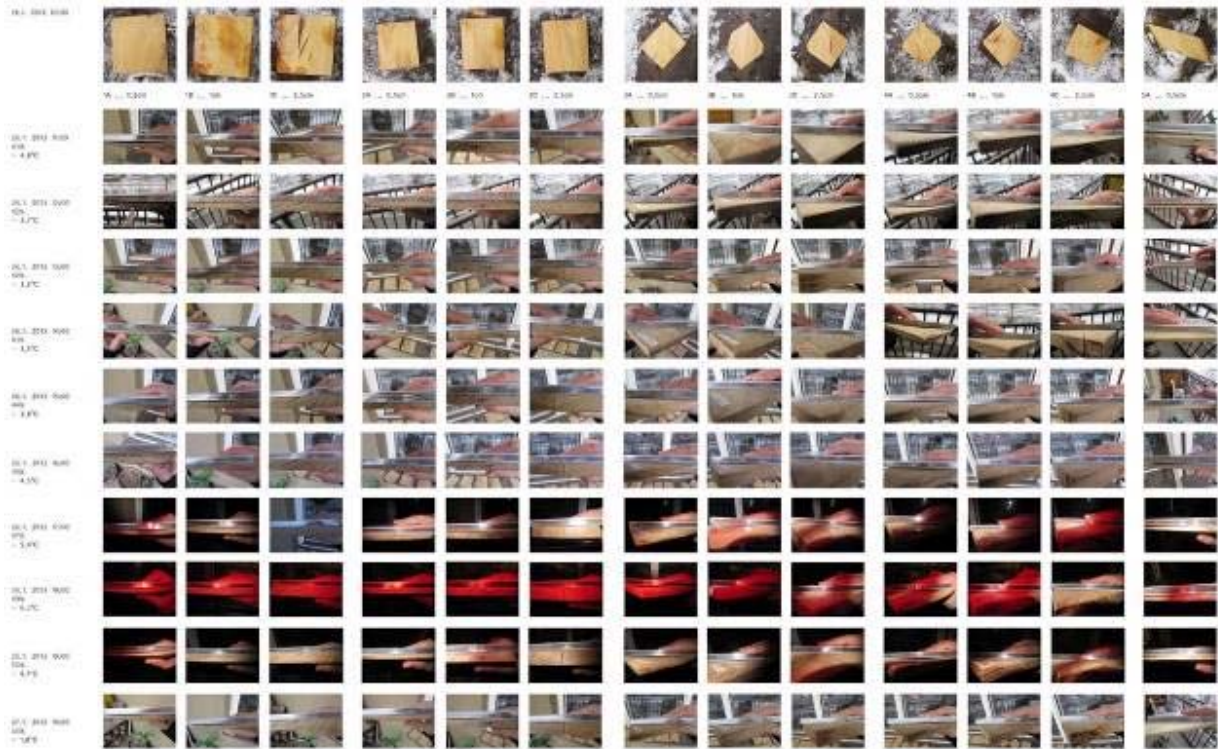


Figure 13: Samples with Different Thicknesses and Shapes of False Acacia Measured from One Morning to an Other (Davidová 2012)



Figure 14: Warping of 0.5 cm Thick Pine Samples in 10% RH and 21°C (Davidová 2013)



Figure 15: Fence with and without Algae Measured with Moisture Meter, Nové Město nad Metují (photo: Davidová 2013)



Figure 16: Samples of Artificial Growth of Apatococcus and Klebsormidium (from up to down) on a) Ash; b) False Acacia and c) Pine Wood from - Left to Right, Respectively (photo: Davidová 2013)

## 8. Prototyping Design-Research Projects

This chapter explains all **prototypes' projects** and their **development performed throughout the research**. Previously, several concepts of the wood relating to **relative humidity** and **temperature** were drafted in a creative, **non-critical mode**. Afterwards, they were undertaken through criticism and developed or put aside. Though **Environmental Summer Pavilions**<sup>21</sup> (see Figure 17 and Figure 18) (Davidová, 2014a, 2014b; Davidová & Prokop, 2016; Davidová, Šichman, & Gsandtner, 2013) project and project **Ray** (see Figure 19 and Figure 20) (Davidová, 2013, 2014, 2016e) keep a certain level of **independence**, they serve to each other as a **different scale, environmental complexity, timeframe and detailing level case studies for observations and design development, informing following prototypes**, using **everlasting 'thinking hand'** (Pallasmaa, 2010) as well as all the other senses (Pallasmaa, 2005) in **feedback loops**. Within the project, **'beauty'** (Hensel, 2008) is also considered as a **factor of architectural performance**, engaging a pleasant **experience** and **emotional relationship** to it of its creators, users and visitors, thus also engaging them for **curiosity** in the research that often **extends into discussion**, thus **design-research's development in co-design**. This factor also serves as a **protection from vandalism**. Beauty is meant here in depth of its **holistic complexity** of the design as a **'performative synthesis'**<sup>22</sup> (Hensel, 2008), somewhat as **'atmosphere'** (Böhme, 2006; Bratton & Diaz-Alonso, 2006; Leatherbarrow, 2009; Pallasmaa, 2016; Rahm, 2009; Zumthor, 2006a), not just an outlook. This **'affect'**<sup>23</sup> in the means of Kipnis' discussion from 2005 (Kipnis, 2011) is used as an **endless**

<sup>21</sup> The Environmental Summer Pavilion I: pareSITE was a result of transdisciplinary half semester studio course lead at the Architectural Institute Prague and the Faculty of Forestry and Wood Sciences at the Czech University of Life Sciences in Prague by me, Martin Šichman and Martin Gsandtner.

The Environmental Summer Pavilion II: LOOP was a result of transdisciplinary one semester studio course lead at the Faculty of Art and Architecture at the Technical University of Liberec and the Faculty of Forestry and Wood Sciences at the Czech University of Life Sciences in Prague by me, Šimon Prokop and Martin Kloda. In both of the cases I was a project leader and manager and key design team member.

### List of Participating Students:

pareSITE: Yuliya Pozynich, Jason Nam, Alena Repina, Daria Chertkova, Yana Vaselinko, Mikkel Wennesland, Dan Merta, Daniela Kleiman, Liv Storla, David Lukas, Christopher Hansen, William Glass, Jiří Šmejkal, Milan Podlena, Josef Svoboda, Tomáš Pavelka, Miroslav Runštuk, Ladislav Rubáš, Radim Sýkora, Anna Srpová, Ivana Kubicová, Gabriela Smolíková, Karel Ptáček, Jan Matiaš, Tomáš Mišoň, Lukáš Růžička, Jan Hyk, Marian Loubal, Jan Dostál, František Juhász and Jakub Vykoukal

LOOP: Alena Novotná, Anna Hrušová, Antonín Hůla, Barbora Slavíčková, Jakub Kopecký, Jiří Fáber, Jiří Pokorný, Petr Tůma, Tereza Jílková, Radim Sýkora, Eliška Antonyová, Tereza Lišková, Filip Janata, Tomáš Kytka, Marie Kortanová, Vojtěch Holeček, Martin Vaníček, Jakub Hlaváček and Petr Havelka

<sup>22</sup> 'The filigree designs and the dramatic display of light and shadow create virtual spaces within rooms. Screenwalls and similar building elements have already consolidated what Reyner Banham called the Western tradition of substantial architecture with the non-substantial one of societies who do not build substantial structures [but instead] inhabit a space whose external boundaries are vague, adjustable and rarely regular. Such elements constitute no less than the awesomely beautiful performative synthesis of the delineating material threshold and the environmental gradient.' (Hensel, 2008)

<sup>23</sup> Kipnis discusses that architectural concept is seen either as social action tool or the fusion of architecture and form or benefit. This divides architecture into two directions: 1. Phenomenology of perception; 2. Representation and the labelling significance. He then fuses the two as

**tool for holistic environmental interaction of 'Time Based Design'<sup>24</sup>** (Sevaldson, 2004, 2017) (see chapters Methodology: Systems Oriented Design and Research by Design while 1:1 Prototyping (6) and Practice Application Discussion (9)). The **Environmental Summer Pavilions** (see Figure 17 and Figure 18) project takes into consideration a **larger view on responsive wood performative capacities** through engaging **diverse** kinds of **public spaces** in its **overall complex eco-systemic conditions**. This required large **trans-disciplinary** and **trans-institutional** teams and **searches for methods suitable** to the project and **available technologies** through **trial-error approach**. Many **failures** have been encountered that have led to **new definitions of the parameters** involved. The project generally suffered from short time schedules and low budgets in comparison to similar projects in the field. However, I believe it brought new topics to the discussion anyway and served well as a **research tool for variety of performance**. **Project Ray** (see Figure 19 and Figure 20) is covering a **complexity of researched area in material-design research** on the contrary to the pavilions project, that are more focused on complexity of its environmental interaction and housing application (see Figure 24). As roughly discussed in Methodology: Systems Oriented Design and Research by Design while 1:1 Prototyping chapter and discussed in larger detail in Sevaldson's upcoming publication Systems Oriented Design (Sevaldson, 2017), it is necessary to **mix media** and **start prototyping in early design stage as an analysis of the project**. Ray 2 (see Figure 19) was **prototyped in very early stage** as a **source for observation** of the problematique within this very **short pre-given timeframe** of PhD research. Thanks to this, several samples, either separately or in **pavilions' environmental complexity**, were developed and researched. This led to way more developed Ray 3 prototype (see Figure 20, Figure 21 and Figure 22), that should be ready for application in practice on semi-interior spaces (see Figure 24, Figure 27, Figure 30, Figure 32 and Figure 33).



Figure 17: pareSITE (photo: Wágnerová 2013)

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affects that are performing as a result of how architecture acts, so as an intersection of it experience and creation of its meaning (Kipnis, 2011).

<sup>24</sup> Sevaldson implies process based performance observations and creations that can be also co-designed as a design performance in real life, therefore co-lived (Sevaldson, 2017).



Figure 18: New Meets Old, Loop Pavilion (photo: Okamura 2014)



Figure 19: System Ray 2 Prototype (photo: Davidová 2013)



Figure 20: System Ray 3 – Prototype (photo: Davidová 2016)



Figure 21: Test of Plugs Based on Wood's Hygroscopicity instead of Glue in Natural Environmental Conditions  
(photo: Bouma 2015)



Figure 22: Test of AZ ThermaCoat Paint (photo: Davidová 2015)



Figure 23: Ray 3 Finalized in Carpenter Workshop, Defio, s.r.o. (photo: Kořínek 2016)



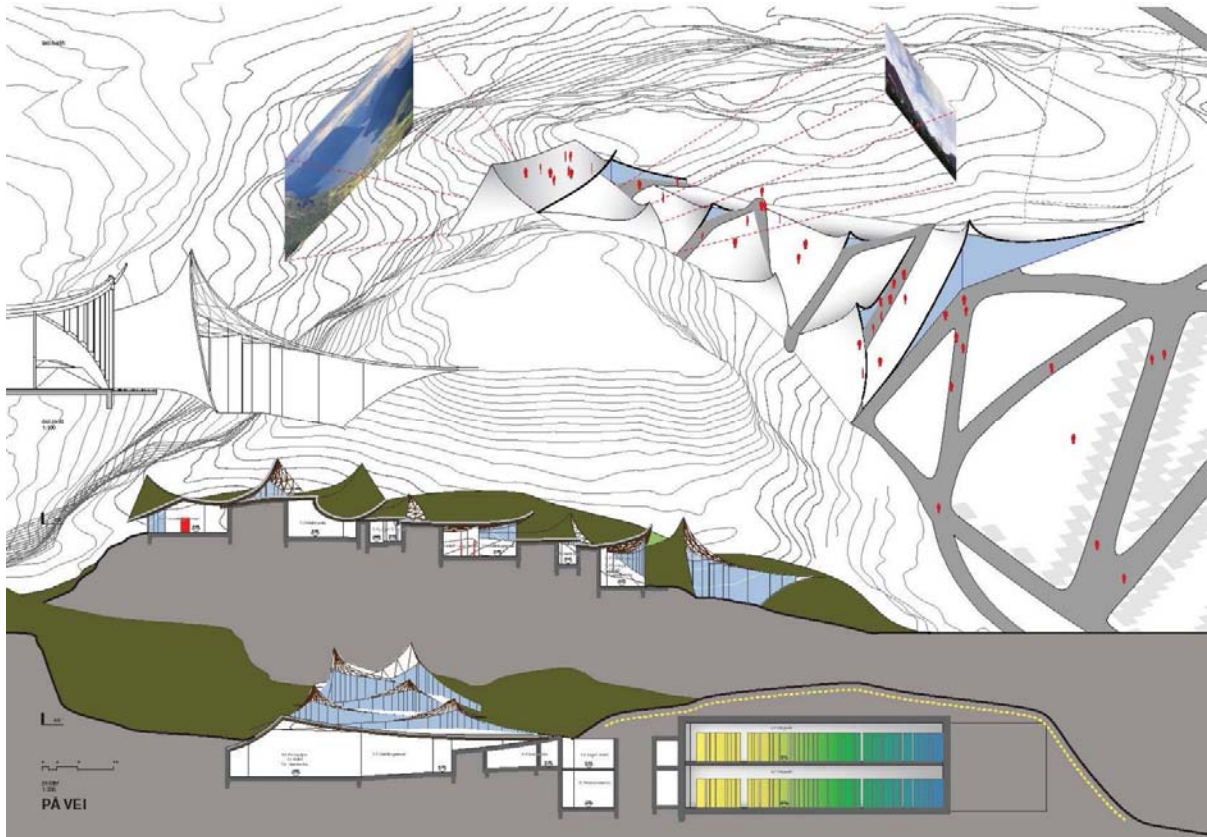


Figure 24: Pã Vei Competition Entry Showing Unclimatized Exhibition Space with Special Environment Needs That Has Been a Motivation for this Research; from up to down: axonometry, detail and sections (Collaborative Collective 2011)

## 9. Practice Application Discussion

This chapter is discussing **today** and **past practice examples** of **non-discrete architecture** in the means of *'active-agency'* of *'context-specific participation'* (Hensel, 2012b), arguing for **penetrable layers of peals within onion principle** (Davidová, 2016e, 2016j), somewhat in the sense discussed by Alexander as a *'...design with a number of nested, overlapped form-context boundaries'* (Alexander, 1964). But it differs from Actor Network Theory by Latour that though bringing non-human agents into play, there is strict differentiation of role among a) human and b) non-human, means biotic as well as abiotic, agents (Latour, 2006). In the last point, this design-research's understanding differs from how it defined by Hensel in his PhD thesis (Hensel, 2012b).

The two selected papers for this chapter argue for **larger equality** of both, **biotic** – including human, as well as **abiotic** factors and actors within the **eco-system** and **environment**, that at the end is also most beneficial to humans. The human world has believed in larger importance of human among the other factors and actors in environment<sup>25</sup> and biosphere<sup>26</sup> for many past years. Therefore, it seems we have reached the point we are now discussing its **future existence**. Governments across the continents, such as Czechia, Norway, Canada, USA and Turkey developed

<sup>25</sup> 'Environment is physical and biological surroundings of an organism. The environment covers non-living (abiotic) factors such as temperature, soil, atmosphere and radiation, and also living (biotic) organisms such as plants, microorganisms and animals.' (Oxford University Press, 2004)

<sup>26</sup> Biosphere is 'irregularly shaped envelope of the earth's air, water, and land encompassing the heights and depths at which living things exist. The biosphere is a closed and self-regulating system (see ecology), sustained by grand-scale cycles of energy and of materials—in particular, carbon, oxygen, nitrogen, certain minerals, and water. The fundamental recycling processes are photosynthesis, respiration, and the fixing of nitrogen by certain bacteria. Disruption of basic ecological activities in the biosphere can result from pollution.' (Lagasse & Columbia University, 2016)

strategies for **climatic change adaptation** (Czech Republic Ministry of the Environment & Czech Hydrometeorological Institute, 2015; Flæte et al., 2010; Republic of Turkey Ministry of Environment and Urbanization, 2012; Richardson, 2010; U.S.Department of State, 2014). All of those I got to study, those that are mentioned, are lacking **holistic transdisciplinary perspective** and if architectural design is discussed, is usually done in the means of increase of impenetrable insulations for most possible enclosed interiors – **'discrete objects'** (Hensel, 2012b), though it is commonly questioned by environmental engineers in practice, that such requirements are reducing any energy consumption. In opposition to non-discrete architectures, such properties are unfortunately even got required by **building codes** of many countries, including Czech Republic where this document is even discussing renovations of traditional architectures in this context (Czech Republic Ministry of the Environment & Czech Hydrometeorological Institute, 2015). **Architectural relation to eco-system** in these documents is represented only by green roofs and possibly facades use recommendation at maximum, not even looking at possible **eco-systemic performance** of this option. **Do we really believe that this will reasonably support our adaptation to predicted climatic changes, such as high and low temperature extremes, extreme droughts or floods, snow or rain storms, etc. mentioned in introduction chapters of all these documents?**

The paper discussing historical and my practise context: 'Socio-Environmental Relations of Non-Discrete Spaces and Architectures: Systemic Approach to Performative Wood'<sup>27</sup> (Davidová, 2016g), presented at the Relating Systems Thinking to Design 5 symposium was placed into **'Human-Centred Settlements'** session. This fact, as it was so confusing to me, helped me to sharpen its point: **To design with having human benefit in the centre of mind, means to design for and with the overall environment, its biotic and abiotic factors. Only this way, we can design truly human centred settlement.**

This paper places the research into overall reflection concerning examples of **my projects in the Performance Oriented Design field** in relation to its **boundary conditions** and **performed biotic and abiotic interaction** utilised in **GIGA-map** (see Figure 25 and Figure 26), a case study example mapping relations in architectural type in reference to world axis, human behaviour and use options, placement and macro and micro climatic conditions of the exchange of exterior, semi-interior and interior in non-discrete spaces in Norwegian traditional architecture, so called **'svalgangs'** (see Figure 27, Figure 28 and Figure 29) and through this analysis, the project's application in the context of the **contemporary living environment in Czechia** for its **climatic adaptation** discussion on today architectural practice.

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<sup>27</sup> This paper was developed under the Systemic Approach to Architectural Performance project (Davidová, 2016g) that was kindly supported by EEA and Norway Grants (EEA and Norway Grants, 2016).

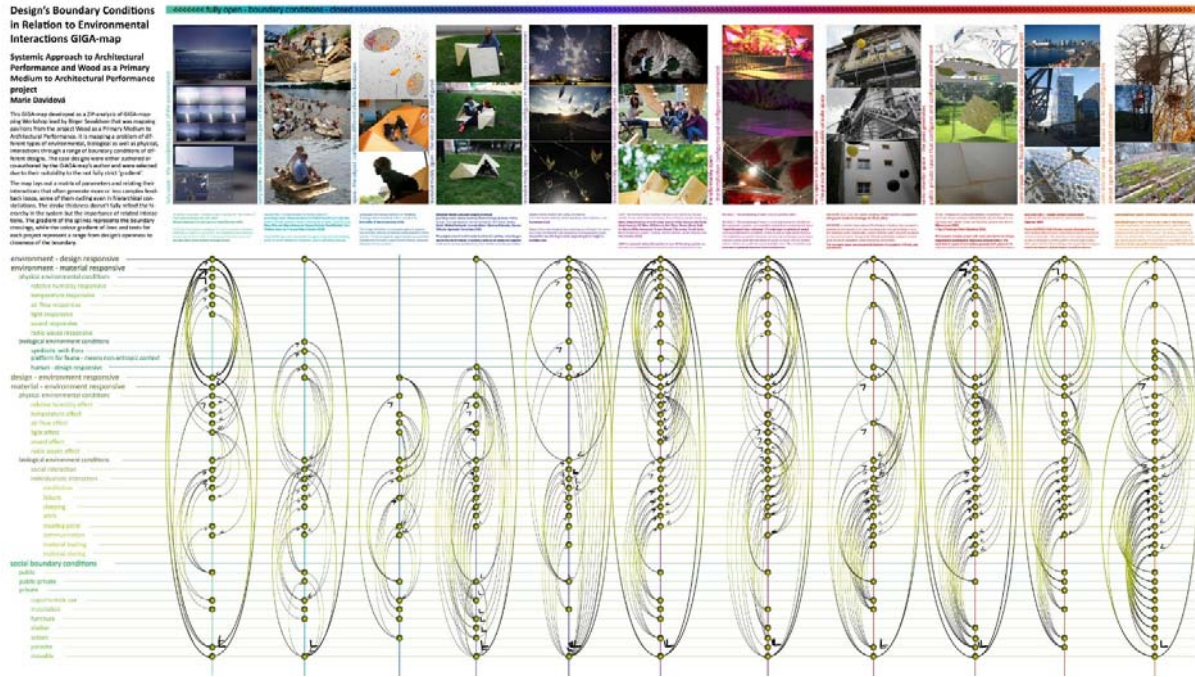


Figure 25: Davidová: GIGA-Map of Design's Boundary Conditions in Relation to Both, Abiotic and Biotic, Including Social, Environmental Interactions, Mapping the Spaces Organized from Fully Open to Almost Closed 2016 – please, zoom in at SAAP blog or in RSD5 proceedings (Davidová, 2016a, 2016b)

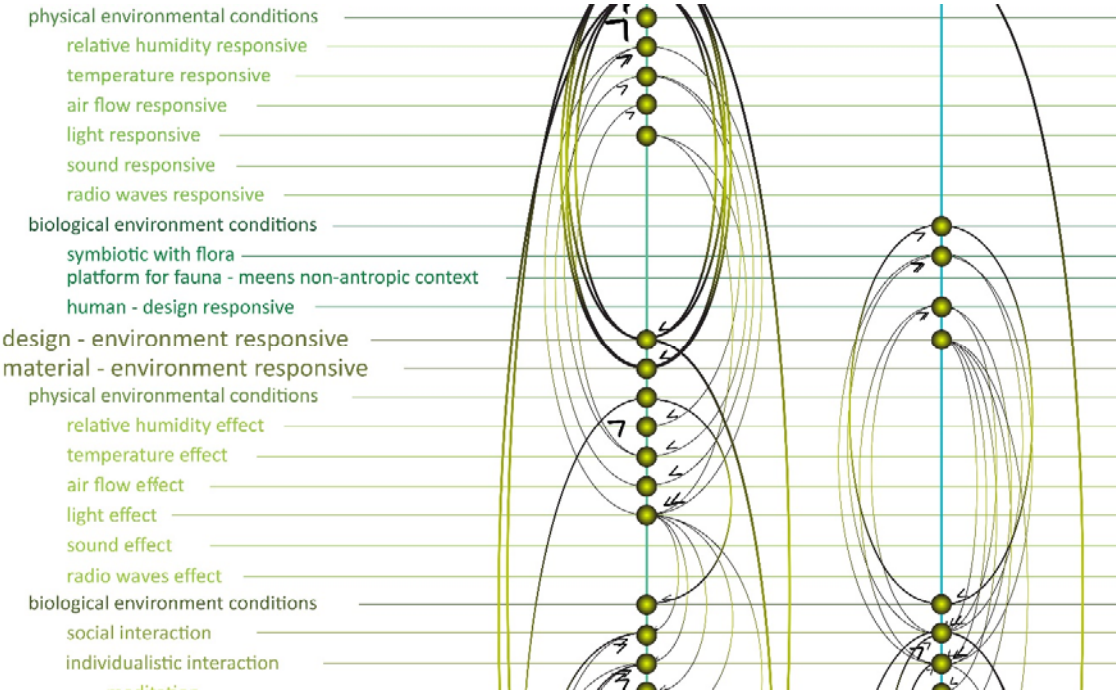


Figure 26: Davidová: Detail of GIGA-Map of Design's Boundary Conditions - showing different interactions, levels and hierarchies in feedback looping among interactions of different parameters through the boundaries. 2016 – please, zoom in at SAAP blog or in RSD5 proceedings (Davidová, 2016a, 2016b)



Figure 27: Svalgang of Hjeltarstua from 1763, recently placed in the Maihaugen Open Air Museum in Lillehammer (photo: Davidová 2016) shows the opportunity of indoor-outdoor environment including the range from social to climatic interaction while working actively.

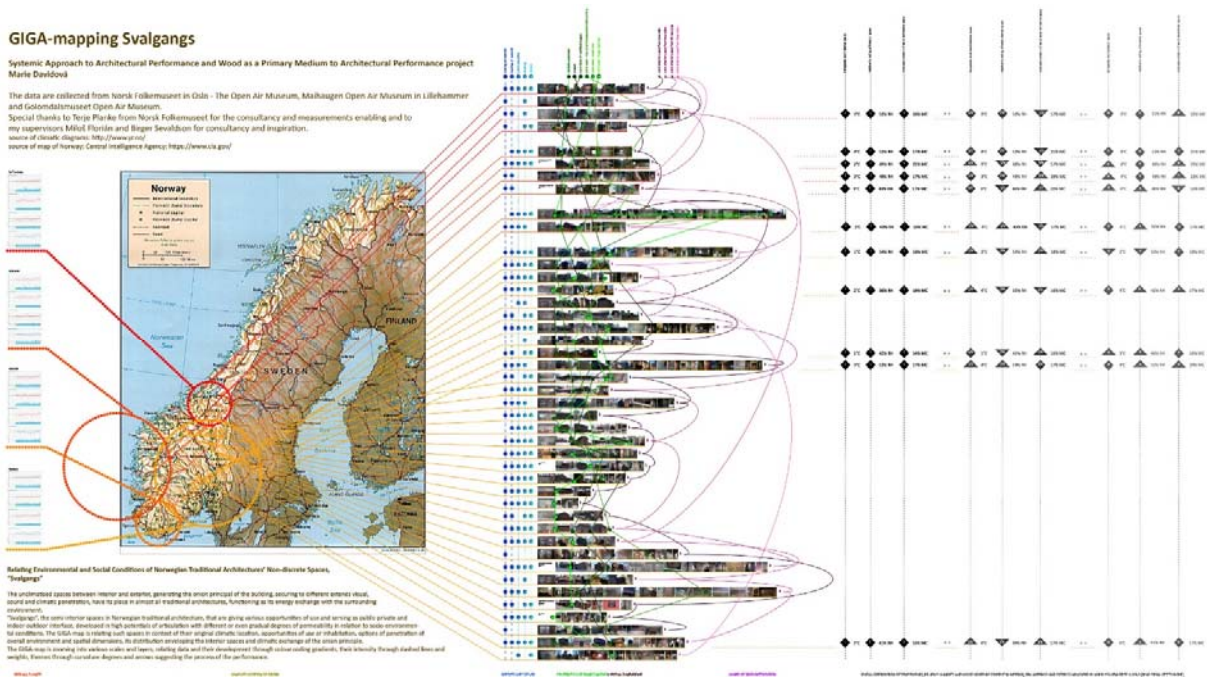


Figure 28: Davidová: GIGA-mapping Svalgangs 2016 (the map of Norway is a public source from: Central Intelligence Agency: <https://www.cia.gov/> the macro climatic diagrams are used with the courtesy of yr.no reached at yr, 2016) – please, zoom in at SAAP blog or in RSD5 proceedings (Davidová, 2016a, 2016d)

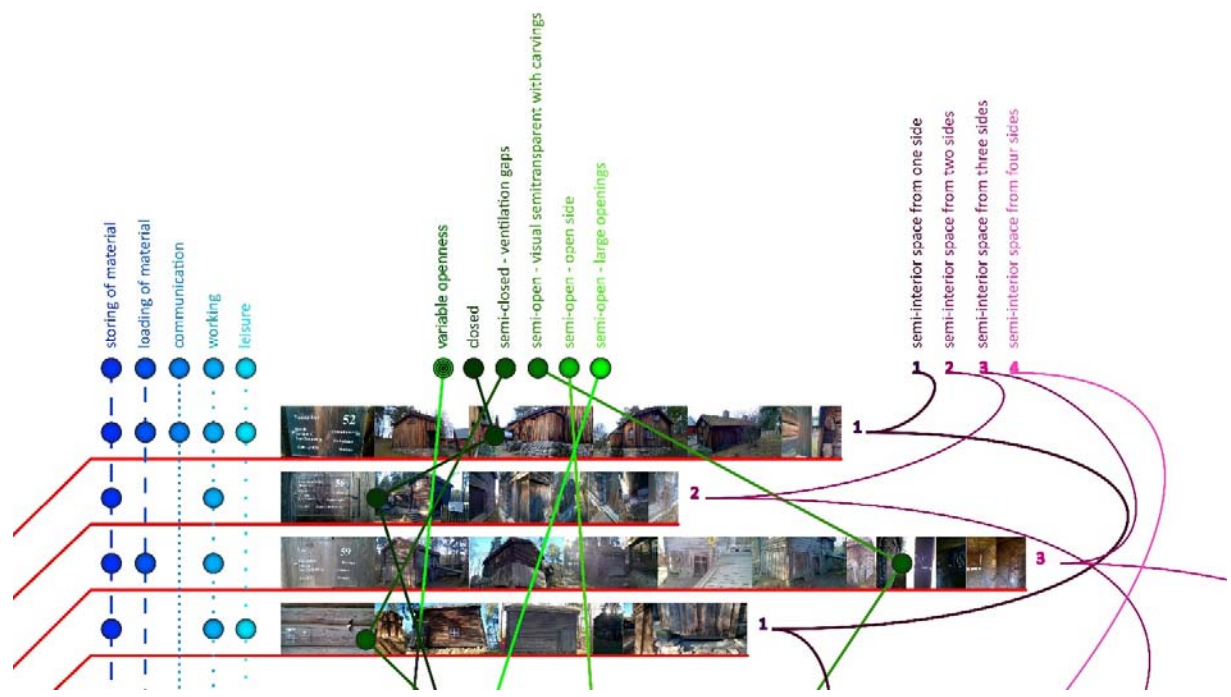


Figure 29: Davidová: Detail of Svalgangs GIGA-Map showing differentiation in relations mapping 2016 – please, zoom in at SAAP blog or in RSD5 proceedings (Davidová, 2016a, 2016d)

The today **practice application of the research-design** project Ray boundary exchange (see Figure 30) was discussed in the **integrated** context of **eco-systemic settlement** in transdisciplinary paper: Responsive Transformer: The Bio-Robotic Adaptive Architecture (Davidová, Zatloukal, & Zímová, 2017), presenting a **competition entry** for design of administrative building for the Forests of the Czech Republic (Lesy České republiky, 2016) (see Figure 31, Figure 32 and Figure 33). The paper questions both, the architectural design – process and ‘result’ as well as the notion of the architectural profession.

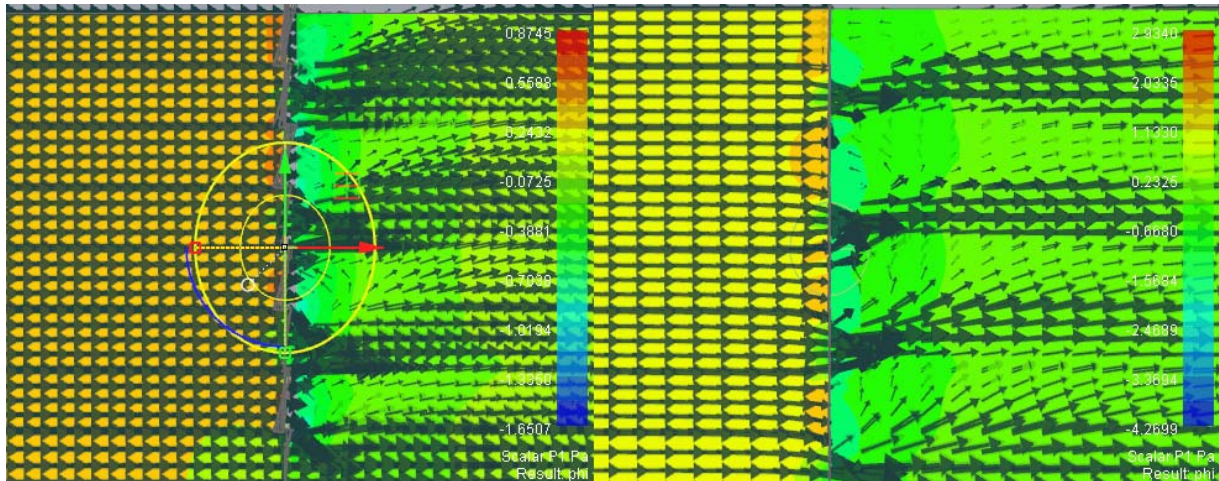


Figure 30: RhinoCFD Fluid Dynamics Simulations Illustrating the Exchange between Exterior and Semi-Interior Spaces through Ray Envelope; a) to the left: situation of dry and hot weather when the screen is open; b) to the right: situation with higher humidity and lower temperature when the envelope slowly closes (Davidová 2017)



Figure 31: Responsive Transformer (Collaborative Collective 2016)

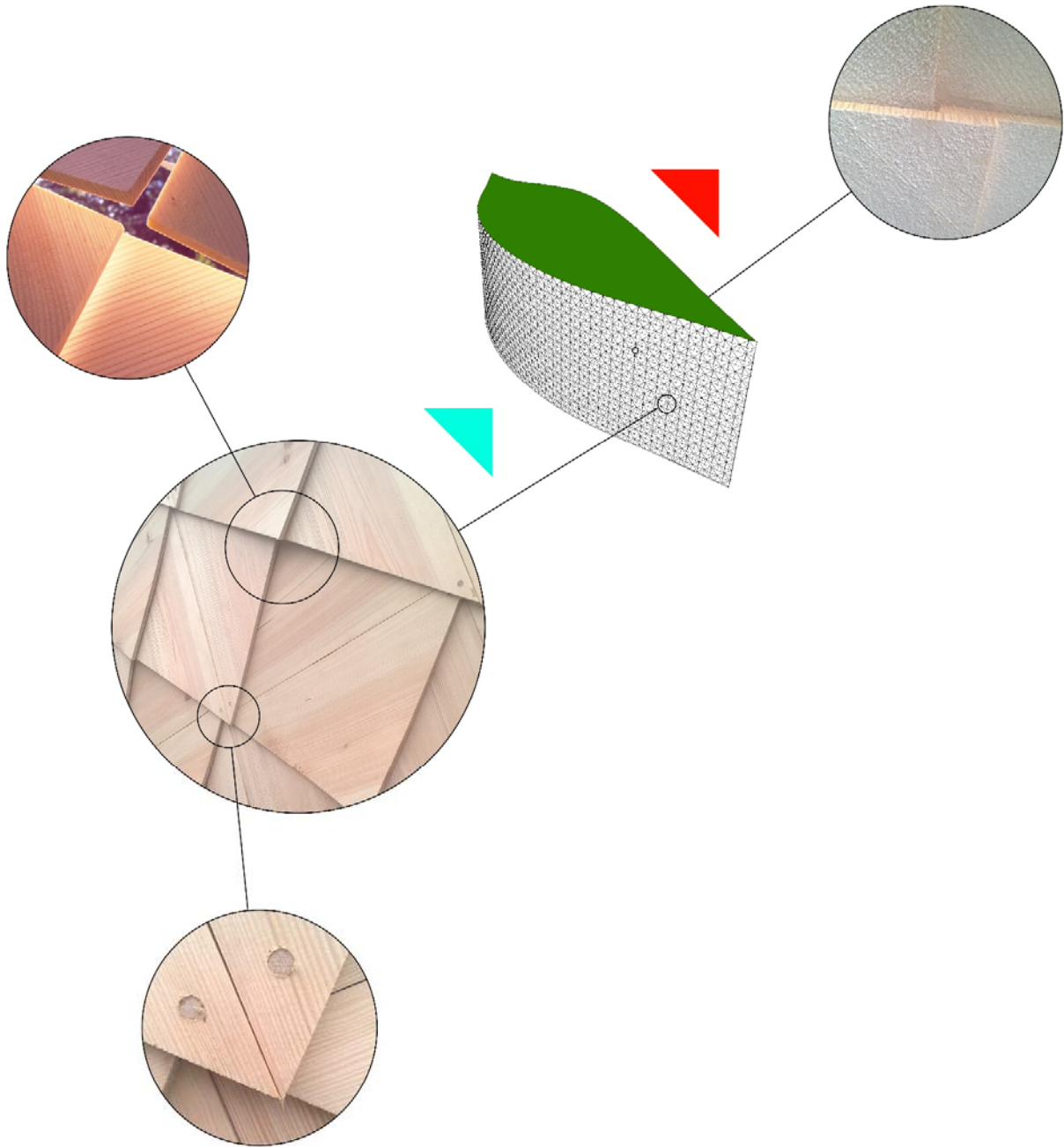


Figure 32: Ray 3 – Responsive Envelope Applied on Cell with Green Roof Showing the Natural Ventilation Stream: a/ top left: Open Airing Gap in the System Ray 2 Prototype; b/ central left: Ray 3 Prototype; c/central right: Ray 3 Applied to Cell; d/ top right: AZ TR Coat on Ray 3 Prototype; e/ bottom left: Joinery on Ray 3 Prototype (Collaborative Collective 2016 and 2013)

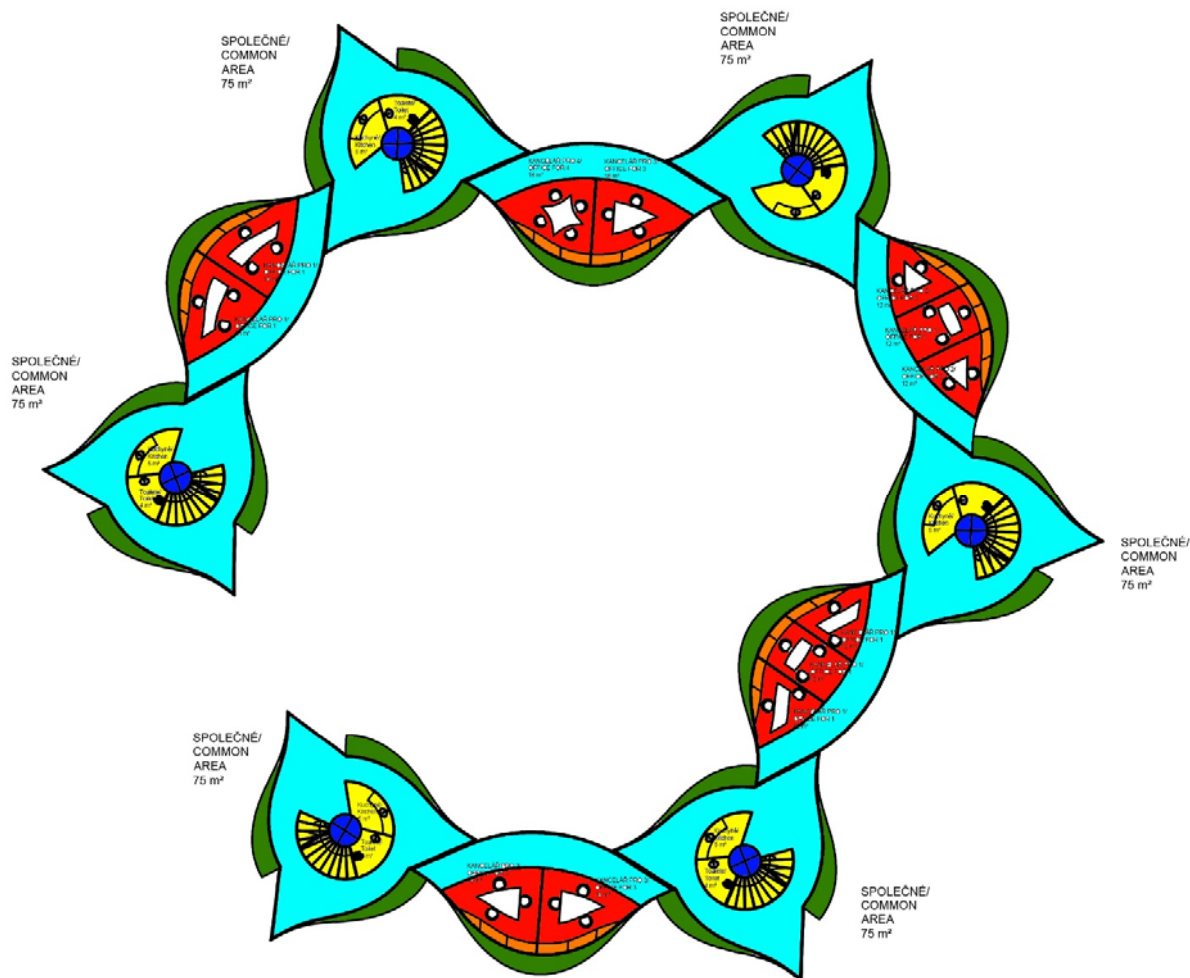


Figure 33: Responsive Transformer: Example of Offices Floor Plan Showing Peels of Bio-Climatic Layers (Collaborative Collective 2016)

## 10. Summary, Discussions and Conclusions of the Thesis

The thesis is to my knowledge the first research exemplifying the field of *'responsive'* (Hookway & Perry, 2006) wood on project practice application and the first to examine this study on solid wood. It is done in the sense of arguing for the option of learning from traditional knowledge through the use of solid wood and architectural *'types'*, researched through GIGA-map as a new *'typological<sup>28</sup> diagram<sup>29</sup>* exploration of *'non-discrete spaces'* (Hensel, 2013; Hensel & Turko, 2015) and human settlements. In contrast to impenetrably insulated enclosed spaces that are propagated today (Davidová, 2009) even by building laws of many countries, the research proposes different layers with various fields (S. Allen, 2009; Hensel & Menges, 2009) of boundaries, serving as active zones of mediation between them (Addington & Schodek, 2005; Hensel, 2012c, 2012d; Hensel & Menges, 2009). It covers important findings in **wood material research**, methodology development in the field of **Systems Oriented Design** (Sevaldson, 2013a, 2013b, 2017), **Time Based Design** (Sevaldson, 2004, 2005, 2017), **co-design with biotic as well as abiotic agents** and **full scale prototyping**, majorly through fusion of these for **Performance Oriented Architecture**. It is a

<sup>28</sup> 'Typology is the comparative study of physical or other characteristics of the built environment into distinct types.' (Güney, 2007)

<sup>29</sup> Jacoby proposed to overcome the existing historiographical separation between a typological or diagrammatic discussion by 'typological diagram', meaning a diagram. that is specific to the discipline of architecture in its production of form and knowledge, and is framed in both tupal and typological terms. This typological diagram should be an abstraction arising from a set of related conceptual, descriptive and design problems (Jacoby, 2015).



transdisciplinary research involving various levels of institutions and social groups suggesting not only different approach to **'architectures'** but also to design **process**, its **methodologies** and **management of such**. This fusion lead at the end into major conclusion – ratification of new design field: **Systemic Approach to Architectural Performance**.

One more PhD project: 'Bio-Climatic Layers in Built Environment: Exploring Environmental Dimensions' in currently undertaken by the author at the Faculty of Art and Architecture at the Technical University of Liberec in art field, bringing this case study project into larger complexity of dwellings and settlements.

## Major Acquisitions to Research Fields Summary

By practising **Research by Design** and **Systems Oriented Design**, the work needed to be **more complex approach than just looking at one focus area**. Though I tried to keep this this thesis **thematically focused**, it had to address **more than one field** for the reason that **neither any method** for the research, **nor the material science** was **advanced enough** or applicable for the project, its **local** as well as **team members' parameters** settings. For this reason, a new **design field**, fusing all the areas discussed within the holistic perspective of real life, was founded. This field is called **Systemic Approach to Architectural Performance**.

### Methodology Research Acquisitions

The following acquisitions in this section are gained through design, fabrication and prototypes testing practice, employing intuition, observations and reflections upon it. These investigations are grounded in research's area and stakeholders' complexity and relations and time basis within it. Within this project, the process and the never ending **'result'** are seen as one within its evolution.

- **MINI-maps:** The research involved MINI-maps and combined them with concept sketch models as a kick start in design-research process.
- **Processing Performance of the Whole:** The research positions tacit and subliminal knowledge as relevant design-research parameter, equal, or often superior to hard data and proposes the strategies for its application from registering through GIGA-mapping to prototyping and its further performance observations, followed by next applications. This is for the reason, that hard data can never cover the complexity of the overall performance of the whole.
- **Performance of the Whole:** The research claims the necessity of full scale prototyping, showing that partial simulations and prototypes often perform other way than the whole, following similar discussion in Gestalt Theory.
- **Rich Design Research Public Space:** The research progresses the synergy of transdisciplinary GIGA-mapping and full scale prototyping, while exposing the work to different performers and public in public space for its co-design, thus generating one more step forward in Rich Design Research Space. This is only possible thanks to the strategy of involving NGO into Research by Design as a key partner.
- **Feedback Looping of Final Prototypes:** The research exhibits practical examples of Time-Based Design, when the final architectures that are already in use are in the same time research's full scale prototypes.
- **Time Based Eco-Systemic Co-Design:** The research exhibits a practical example of Time Based Design through prototypical built environment, that is co-designed and re-designed by its users, including all biotic and abiotic factors in eco-system, over time.
- **Practice Generated Theory:** The work claims to generate theory through practice.
- **Systemic Approach to Architectural Performance:** Through the fusion of Performance Oriented Architecture and Systems Oriented Design with time based ever evolving eco-systemic co-design perspective that involves all biotic and abiotic agents, the research ratified new design field.

## Material Research Acquisitions

The following acquisitions in this section are gained through samples and environment hard data observations and rating these to forestry, microscopic wood material science research and craftsmanship. Spoken knowledge had to be collected for the reason that not enough has been published in the field. This could be also claimed as one of the acquisitions, as this knowledge is seriously disappearing.

- **Life Cycle Based Eco-Systemic Material Selection:** Pine wood seems to be most suitable for discussed design properties in researched location, considering local pine species and local eco-system.
- **Force-Hygroscopicity Relations:** It seems that the stresses within the material, followed by its growth material distribution have direct relation to wood's hygroscopic behaviour, namely its warping. This was largely observed on samples of tension wood of false acacia and in smaller extent on narrow samples of pine wood.
- **Time-Based Force-Hygroscopicity Relations:** About 10% of the samples warps other direction for certain time after the wood is cut (about three months) on observed samples. This might be for the reason that the stresses of the overall tree stays in the material.
- **Angle Cut-Fibre Direction Hygroscopicity Performance:** Not only the thickness and density of the material, but also the angle of plane cut in reference to fibre direction affects its cup warping of the observed samples.
- **Sugar and Amyl Free:** The material can be protected against biological decay by soaking to salt water before it is applied. For better data within the researched location it would need testing periods that widely extend the scope of this research project. Related evidence of this protection is from Norway on its traditional panelling, even from very humid locations. However, it is impossible to claim same performance in the research area with its climate and biotic specificity and different morphology of the proposed design itself, therefore its interaction with the environment. It seems to be the most sustainable treatment for such wood protection. Therefore, more investigations in this field sound reasonable.
- **Biological De-Re-Sorption Relation:** Algae habitation has decent effect on material's moisture content, while it distributes along the fibre orientation and the morphologically defined moistest locations of the samples.
- **MC-Cut Hygroscopicity Relation:** The material's performance can be partly pre-programmed by setting certain moisture content when it is cut.
- **Responsive Material-Design Life Cycle:** At least in researched location (Czechia), the solid wood has currently more sustainable life cycle than the ply-wood within the field of proposed design.
- **Introduction of Solid Wood Responsivity to POA:** Solid wood can be applied in Performance Oriented Architecture as climate-responsive material.

## Architectural and Urban Design Research Acquisitions

The following acquisitions in this section are gained through design-research speculative practice and traditional architectures' and prototypes' observations and hard data collection. Those were elaborated by its reflective analysing through GIGA-mapping or tacit and subliminal experiences. The speculative practice concepts part is generated through observational, registering and mapping experience for building new theory.

- **Responsive Solid Wood's Application:** The research suggests two practical applications of responsive wood for non-discrete architectures: a) Semi-interior spaces of dwellings exemplified on two competitions entries by my practice platform Collaborative Collective where the designed screen is applied. This design solved major practice application questions of the basic research done by the other researches. b) Urban design of climate-active pavilions that were built and observed in the city of Prague, serving as micro-climate modulator, public life activator, as well as i.e. repose object for birds in dense city centre. In all these cases I was the project leader and manager, as well as a key design team member.
- **Performance Based Beauty – Beauty's Performance:** While i.e. Hensel or Zumthor claim that beauty is coming out of the performance (Hensel, 2008; Zumthor, 2006b), the research is adding a claim, that beauty also performs, such as we know it from biology. And that it can serve as a critical design-research tool or architectures' 'protection'.
- **Embodied Architectural Performance:** The research integrates environmental and bodily performance of architectures.
- **Boundary Conditions Crossing:** The research maps and claims climatic performance of semi-interior spaces of traditional architectures in Norway arguing for its biotic and social aspect.
- **Onion Principle:** The research concludes on need of different understanding of build environment – not as a strict differentiation of exterior and interior, but as an onion principle of different fields of exchange among its layers.
- **Eco-Systemic Environmental Interaction Principle:** The research maps biotic and/with abiotic interactions through different levels of enclosures of architectures claiming better human and social performance when more environmental factors and their larger variety is employed. This argues for the route of non-anthropocentric architecture which in fact gains largest benefits for humans and is in that way human-centred in the same time. In the same time, it argues for the multiple approach of this thesis.
- **Trans-Co-Design:** The research proposes and exemplifies different understanding of architectural practice as it is common in discussed location. It is rejecting the role of master architect or mastering architects' teams and her/his/their design ruling the game but suggesting transdisciplinary over evolving process of co-designing overall eco-system with both, biotic and abiotic agents, including humans.
- **Local Climatic Adaptation:** By doing all mentioned, the research suggests a route to architecture adapted to climatic changes in researched location.
- **Systemic Approach to Architectural Performance:** Through the fusion of Performance Oriented Architecture and Systems Oriented Design with time based ever evolving eco-systemic co-design perspective that involves all biotic and abiotic agents, the research ratified new design field.

## Discussions and Conclusions of Closing Chapter

It is no wonder that UN agenda for 2030 sustainable development that is by the way titled *'Transforming our World'* is calling for **collaborative partnership of all stakeholders** and **fight of poverty**. Further on, this document is determined to ensure that economic, social and technological progress occurs in **harmony with nature** to reach prosperity (United Nations, 2015). However, as it itself states, this document is *'people-centered'* (United Nations, 2015). Its goals are so anthropocentric, that *'Cities and Communities'* are discussed in separated goal (United Nations, 2015, 2016a) from bio-diversity, discussed in *'Life on Land'* goal. The later one is in return not addressing the first mentioned (United Nations, 2015, 2016b). This work aims to demonstrate, that only when we **stop placing human kind into our main focus**, we can move closer to the achievement of the *'sustainable development in its three dimensions – economic, social and environmental – in a balanced and integrated manner'* targeted by this declaration (United Nations, 2015). The declaration has one important point that is also crucial to this work: it is calling for *'adaptation'*<sup>30</sup> through *'transformation'*<sup>31</sup> (United Nations, 2015), not through *'change'* or *'revolution'*<sup>32</sup>.

In 2008 a special issue of Architectural Design called *'Neoplastic Design: Design Experimentation with Bio-Architectural Composites'* was released, where in introduction paper Cruz and Pike states:

*'Neoplastic Design does not purport to put forward a complete vision of the future wherein architecture is fully replaced by neo-biological conditions, but rather an evolving scenario in which pre-existent, more traditional surroundings will be infiltrated by it, creating new hybrids and composite living environments.'* (Cruz & Pike, 2008)

In 2009 Petra Blaisse asked:

*'If our interest in the procedures and methods of nature resettles, then why not introduce biology into our work and into architecture literally?'* (Blaisse, 2009)

I would ask: Why not to **be inside of processes** of its **eco-systems** as *'living environments'* in itself which we would call *'our work and architecture'*? I would like to strictly stress out the distinction from the term *'engineering ecologies'* (Trummer, 2008) for the reason that ecologies, or eco-systems, cannot ever be engineered but lived. And thus the life becomes the design process.

The presented project *'Wood as a Primary Medium to Eco-Systemic Performance: A Case Study in Systemic Approach to Architectural Performance'* is to my belief, taking a step in such, though rather small one as being a particular case study. However, it is ferly targeting the direction through **methodology, material research** and its eco-system and their acquisitions to **architectural and urban design research**, that as a field is in the end questioned by the theory it itself generated. Though architecture and urban design are being referred to as the most complex professions, my work concludes, that it is still not enough. Therefore, we also cannot consider reductionist perspective in its design-research profession. This work fuses methodology, material and architectural and urban

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<sup>30</sup> The Principle of Adaptation: For continued system cohesion, the mean rate of system adaptation must equal to or exceed the mean rate of change of environment (Hitchins, 1992).

<sup>31</sup> Transformation: '1. the act or process of transforming. 2. the state of being transformed; 3. change in form, appearance, nature, or character; 4. Theater: a seemingly miraculous change in the appearance of scenery or actors in view of the audience; 5. Logic: Also called transform. one of a set of algebraic formulas used to express the relations between elements, sets, etc., that form parts of a given system; 6. Mathematics: the act, process, or result of transforming or mapping. function (def 4a); 7. Linguistics: transformational rule. the process by which deep structures are converted into surface structures using transformational rules; 8. Genetics: the transfer of genetic material from one cell to another resulting in a genetic change in the recipient cell; 9. a wig or hairpiece for a woman.' (Dictionary.com, 2017)

<sup>32</sup> 'This word is commonly used to refer to a sudden overthrow of the status quo and its replacement by an entirely different state of affairs. That the word is also used for the turning of a wheel conveys this sense of social arrangements being turned upside-down. Many believe in the necessity of revolution for a fundamental reformation of society. The argument is that existing political and social institutions must be swept away if better ones are to emerge. Democratic SOCIALISTS and the reformist left prefer the idea of change achieved gradually by an incremental transformation of society, mirrored by changes in individual consciousness and behaviour. Finally, a revolution may be conceived not as a deliberate strategy so much as the emergent effect of other social, political and economic changes, as in the industrial revolution.' (Parker & Fournier, 2007)

design into one **Performative Eco-System** and is giving birth to new design field: **Systemic Approach to Architectural Performance**. As stated, it is not engineering project where the interaction would be 100% pre-programmed as the material and its environment is far too complex for this and it even hasn't been the project's aim. It is rather focused on prototypical environment modulating interventions to generate responsiveness and thus performance within given eco-systems.

## 11. My Bio:



Figure 34: Me in front of the LOOP pavilion at the Press Conference (photo: Exner 2014, with the courtesy of City Council of Prague)

**Marie Davidová, MArch.** (see Figure 34) is a founding member and chair of **Collaborative Collective**<sup>33</sup> practice design-research network and NGO, PhD research fellow at the **Faculty of Art and Architecture at the Technical University in Liberec** in the visual arts field; and in the architecture and built environment field at the **Czech Technical University in Prague, the Faculty of Architecture**, studio FLO|W, MOLAB department, where she is also scientific consultant in studios FLO|W and PET-MAT. She gained her master's degree in architecture at the **Oslo School of Architecture and Design** under the supervision of Birger Sevaldson and Per Kartvedt. Marie had been working as an architect in practice studios **Snøhetta** and **Expology** in Oslo and researching and teaching as a university lecturer at the **Faculty of Architecture and Fine Art at the University of Science and Technology in Trondheim**. She has been the visiting

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<sup>33</sup> Collaborative Collective is a collective of architects, designers and friends, first conceived in 2008 as an open platform for sharing ideas and pursuing personal agendas. After this first formation broke up, the team without its establishing founder got rise to different platform called EDIT!. This platform also, deservedly, refers to the former Collaborative Collective's work. In 2011 Křištof Hanzlík, the former founder of the previous platform, and me ratified a design-research network practice with this name under the agreement of the former platform members. This network already started with its own physical office, while outsourcing external transdisciplinary collaborators. In 2012, me, Křištof Hanzlík and Martin Gaberle founded and registered an NGO with the same title as a civic association for science, research and development within the architectural field.

transdisciplinary studio course leader at the **Architectural Institute in Prague** and at the **Faculty of Art and Architecture at the Technical University in Liberec**, both in cooperation with the **Faculty of Forestry and Wood Sciences at the Czech University of Life Sciences in Prague**.

Marie has founded the **Systemic Approach to Architectural Performance** field that joins in the fields of **Performance Oriented Design** and **Systems Oriented Design**. She has held guest lectures and workshops in this field across **Europe**, **North America** and **Asia**, where she is also widely published.

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