Contents

04 FOREWORD
By Editors

07 RESEARCH PROJECTS
Early Stage Researchers’ Work Progress

93 PANEL DISCUSSION DIALOGUES
Interviews between Early Stage Researchers

137 INDUSTRY PARTNER DIALOGUES
ESR’s Interviews of according Industry Partners

171 SMITH SUMMER SCHOOL

175 HENN WINTER SCHOOL

191 SECOND YEAR COLLOQUIUM
Col·legi d’Arquitectes de Catalunya

202 EXHIBITION “PROTOTYPES”
Institute for Advanced Architecture of Catalonia

219 ACKNOWLEDGEMENTS
The Second Year Colloquium was hosted by IAAC, the Institute for Advanced Architecture of Catalonia, in Barcelona for the month of February 2018. The Institute for Advanced Architecture of Catalonia (IAAC) is a centre for research, education, production and outreach, with the mission of envisioning the future habitat of our society and building it in the present.

Early Stage Research (ESR) Projects were presented at COAC, the Col·legi d’Arquitectes de Catalunya. The Catalan organization dates back 80 years of establishment in society as a benchmark for architecture, enjoying national and international collaborations. The Association’s mission is to uphold the social value of architecture and city planning on behalf of society as well as architects. Following the three day event of presentations networking, the congruent exhibition of ‘Prototypes’ was presented at the IAAC Atelier, P59.

The three day event consisted of presentations and discussions with the ESRs and guest speakers, industry partners, collaborating institute leaders and a general audience, in accordance to the three research packages presented: Communicating Research, Simulation for Design, Materialising Design.

ESRs shared their development on their physical prototypes, simulations and the feedback loops between hardware and software. Industry Partners were interviewed about their perspective of working with PhD candidates on research development while simultaneously using their technologies in real world projects. How can this experimental method of development be mutually beneficial for both progressive companies while also working on the preparation of advanced students for the ‘real world’?

Dialog between the ESRs, their research supervisors, the Industry Partners, as well as general audience has been transcribed for the purpose of presentation in this journal. Furthermore, this journal edition includes the experience of educational events that have taken place this year such as the Winter School, hosted by HENN Architects as well as the Summer School hosted by Smith Architects.

Moving forward, the ESR’s will be recording their PhD findings in written format while preparing for the upcoming final exhibition in Copenhagen hosted by CITA, the Centre for Information Technology and Architecture.

Editors:
Mathilde Marengo, Lili Tayefi
Communicating Design

WORK PACKAGE #3
LED BY JAN KNIPPERS

Jan Knippers  Professor at the University of Stuttgart, ITKE
The concept of adaptive architecture has been introduced by J.G. Ballard in 1962 with the short story ‘The Thousand Dreams of Stellavista’ talking about the psychotropic house which adapts to the state of mind of its inhabitants. In the last five decades the principal idea behind it hasn’t changed but integrated spatial adaptation in daily architecture remains a future prospective. Smart materials open up a large possibility but remain limited by scale to this day, while large actuators and/or mechanical details overcome this scale, the input force needed for actuation is discussable in relation to output transformations. The key words for adaptive architecture are dynamics, evolvement, interaction and responds. These elements are used to transform the space through communication between surrounding and user.
Material efficient and lightweight architecture have their roots in ancient tent structures. A combination of bending-active elements together with a membrane introduces new integrative solutions into the design space of adaptive structures, by using their multiple states of equilibrium within bending-active tensile hybrid systems. The current problems with bending-active tensile structures, i.e. the complex modelling, analysis, fabrication, construction and detailing, restricts these structures to be built in a larger scale and have so far been strictly built in a research and educational environment.

The advent of more complex structural system integrating bending-active components demands new strategies to fully expose the design potentials hidden by these structures. This can be addressed by increasing design interactivity and intuitive modelling modifications during complex numerical form-finding routines.
How can the notion of feedback provoke a relationship between early-stage design and industrial fabrication of free-form timber structures?

This research investigates the integration of free-form glue-laminated timber into contemporary architectural design and fabrication. Advancements in material sciences, digital design tools, and fabrication techniques have added an unprecedented amount of complexity to the design and production of buildings. This novel condition necessitates alternate ways of conceptualizing and managing the design-production process and has made obvious the need for integration across disciplines, specializations, and scales. This also presents an opportunity to re-examine a complex material such as timber in a new light.
The project proposes that, through several distinct forms of feedback, new material and design practices emerge that take advantage of the material complexity of timber. New morphologies are made possible by the integration of digital sensing and scanning into existing industrial timber processes, and the breadth and scope of design possibilities are expanded by the development of material- and fabrication-aware design modelling tools. These result in new methodologies which challenge existing ways of designing and fabricating timber buildings.

Close collaboration with the industrial partners has resulted in experiments which test this proposal. A series of motion capture and 3d scanning experiments resulted in a laser scanner prototype which was integrated into an active timber production through hardware and software interfaces. Several design projects were used as case studies to explore new ways of simulating and designing with free-form timber in early-stage architectural design phases.

FIG. TOP Integrating material performance in free-form glue-laminated timber assemblies.
This project investigates the integration of computational fluid dynamics (CFD) simulations in computational design and its potential in driving the optimization of natural ventilation performance in buildings. Specifically, it looks at how shape optimization techniques using CFD can be applied to drive performative forms in architecture.

A number of initial design experiments have demonstrated the limited integration of CFD in mainstream computer aided architectural design (CAAD) software. Driven by this conclusion, the project has focused on the integration of CFD, to allow designers to get performance insight on airflow related objectives within their computational design framework. A fast feedback CFD solver (FFD) has been developed for Grasshopper and compared to the established RhinoCFD solver in...
Rhino through a number of workshops to assess the impact of CFD in the design process. By surveying participants and professionals, an in-depth analysis on the trade-off between designers’ expectations and domain knowledge is attempted. Using as a case study the abandoned courtyard spaces of the typical multistorey buildings in the historic center of Athens, Greece, the project also employs shape optimization techniques, used for localized retrofitting interventions to increase the air quality of the courtyards and the ventilation performance of the buildings. A comparison of the developed FFD solver and OpenFoam’s shape optimization capabilities helps assess the potential of CFD in form finding for architecture. Through the collaboration with the industry partners, the developed methodology is to be tested within the high-end computational capabilities and demanding project cycles of the industry.
Interactive Multiple Criteria Search in Early Design Phase
ZEYNEP AKSÖZ

MULTIPLE LEVELS OF HUMAN COMPUTER INTERACTION FOR MULTIPLE CRITERIA DESIGN EXPLORATION

The involvement of machine intelligence carries the process of design into a new association between two species which continuously influence each other during the search for an ideal design solution. Such design methodology is of high importance for a more integrated information rich and creative design thinking.

The research is focusing on development of multiple criteria search tools that can accommodate the ambiguous nature of the early design phase while keeping the awareness on design performance. The design development and communication can occur on different levels during the early design phase.
The research intends to bring these design methods into a next level while keeping the act of design natural but extending it by integrating machine intelligence into the design process. The high-performance calculation abilities of the machine can generate a new design exploration and design communication environment for the designers, which derives the base layer information from designer’s interaction with the computer but extends it by using multiple criteria search processes. This way the design can reach a new level of controlled complexity which may not be possible without the involvement of artificial intelligence.

In this phase of the project representation of design as physically collected analysis data was investigated. In collaboration with Alexandre Dubor, Kunal Chadha and Raimund Krenmüller from IaaC a set of experiments were developed to collect the physical data. Consequently, this data was used to train a Neural Network that can predict the performance of new models, that were generated by an interactive evolutionary learning algorithm by extending the solution space basing on the designer’s tacit knowledge. As a result, solutions encountered within this new set were far more complex, displaying similar or better performance than the manually designed samples.
ESR 05
Reimagining The Design Process From The Internet Up
DIMITRIE A. STEFANESCU

Speckle.Works is an open source initiative for developing an extensible Design & AEC data communication protocol and platform.

Communication is an essential activity that permeates the design industry in all its aspects, from ideation to materialisation - from the drawing board to the shop floor. The contemporary context involves a growing number of stakeholders from various backgrounds that, through their interaction, enable the definition and subsequent solving of design problems at various scales, thus ultimately leading to the production of the built environment.

Current design communication solutions are cumbersome and impose collaboration models that add a lot of friction to the design communication process.
As such, Speckle emerged as a community driven flexible set of software tools that can provide a base on which custom, domain specific (and even project-specific) design communication protocols and workflows can be built, coming both from AEC industries as well as other design related trades.

Data rich design workflows between any stakeholders (technical or non-technical) lie at the core of Speckle. As there is no such thing in AEC as “one model”, equally there is no “one standard”: Speckle pioneers new ways of delivering custom object models to other design stakeholders in a managed & curated way, without sacrificing privacy or transparency.

Speckle’s contribution to AEC lies in opening up new design data exchange paradigms that enable a fluent design process that diffuses the classical boundaries between design stages and empowers all stakeholders.
Simulation for Design

WORK PACKAGE #4
LED BY ULRIKA KARLSSON

Ulrika Karlsson Professor at KTH Royal Institute of Technology
Quitting the tender phase of large-scale and complex architectural projects does not necessarily implicate that all digital objects have been actually “frozen”, meaning that the geometry is fully generated and accessible. Those will be further design-processed during the post-tender phase, until the materials used and available machines are perfectly known and the fabricator actually needs specific data (before and during construction). This data is generally very expensive, since it takes time to generate, organize and share among all trades. The usually tight time-line framing a large-scale and complex architectural project has an important influence on how the
Hard deadlines require high productivity preventing therefore the possibility to organize all computational processes within a neatly designed Directed Acyclic Graph (DAG) based workflow. Indeed, trying to encapsulate the full complexity of the project’s database within one single pipeline would most probably take more time than completing the project itself, especially when we know that the AEC industry is fragmented through many different software platforms used by the various stakeholders. Therefore, the different trades need to come up with their own custom methods, interoperability tools and quick “shortcuts” in the design process, producing redundant models and files in order to communicate with others and across different software environments.

The present research project discusses the state of the art in data-modelling workflows for large-scale, complex architectures and proposes a Multi-Scalar Data Modelling framework to build, assemble, hierarchize, visualize and access the data handled during the modelling and fabrication processes of such projects.
Collaboration with industry is a vital part of this research since it aims to produce innovative solutions which can be realized in state-of-the-art projects of construction industry.

Given that the main question of this research is how to scale up adaptive shape-shifting structures, the first collaboration with Blumer Lehmann focuses on a big scale (5x5 m) sun-shading sliding structure which can be stored flat during winter and self-organized in a programmed doubly curved form due to gravitational loads when cantilerening.
The challenge of this project was related to the fabrication of complex shaped linear wooden beams with relatively small cross sections (40x60 mm) with a Hundegger K3. Hundegger K3 is an industrial milling machine specialized on shaping wooden beams rapidly, with a constraint of minimum 90 degrees angle for lap joints.

Although the cross sections of beams for standard wooden constructions vary from 60x60 mm to 500x500 mm, the machining needed is minimum and constrained to simple lap joints or holes for metallic elements. On the contrary, in order to smoothly machine the adaptive-stiffness beams discussed in this research, their initial zig-zag lap joint geometry had to be questioned.

Trial and error fabrication strategies followed with different milling geometries and cross sections. The main problem was the lightness of the inserted beams (40x60 mm) which became crucial when the beam was being milled while cantilevering. High vibrations were induced and resulted in low milling quality, inaccuracies and ultimately breakage of the beam (see photo above).

Subsequently, bigger cross sections -milling simultaneously two elements out of one beam- and rectangular lap joints were introduced to the system which led to a smooth, fast and precise fabrication.
Lorem ipsum dolor sit amet, consetetur sadipscing elitr, sed diam nonumy eirmod tempor
Digital Tools for Architectural Composite Design

Coreless Filament Winding (CFW) is a novel process for the fabrication of Fibre Reinforced Polymer (FRP) structures that has been under development at the ITKE and ICD, University of the Stuttgart since 2012. The system involves the additive winding of continuous glass and carbon fibre filament bundles around a minimal skeletal framework. During winding, the sequentially-placed fibres interact with one another and the resulting intersections define the component geometry and structural performance. The design process for CFW has previously been based on background knowledge from researchers supported by multiple stages of physical prototyping at
design iteration for coreless-wound parts, this research project is developing descriptions of the physical and geometric rules behind fibre interactions and developing digital design strategies and lightweight simulation tools for designers to experiment with.

The research has been progressed through large-scale case demonstrators, several small-scale master-thesis studies and a prototyping projects involving industry partners. The projects in figures 1 to 3 show a range of projects with different methods of geometry-creation, structural optimisation and fabrication. However, all utilise CFW to create architectural components and relied on similar digital design strategies to support their early-stage design development.
The ongoing PhD research investigates an alternative fabrication model for the industry of prefabricated concrete that has a potential to level the industry’s performance up to the contemporary standards of lean production. The investigated concept is based on the use of molds made of ice for casting structural concrete components of non-standard geometry. Employment of ice resolves the problems of material waste and manual labor at the stage of formwork dismantling, that is a big advantage in comparison to the conventional practice. Additionally, robotic processing of ice in a form of CNC-milling allows automation of formwork production at a relatively low cost.
The tradeoff is the fabrication environment has to be kept at negative temperatures. However, research around the energy consumption of refrigeration has shown that these expenses won’t exceed benefits of the proposed fabrication process in whole.

The main goal of the research is to highlight the opportunity for a more inclusive structural design of concrete constructions facilitated through ice used as the formwork material. As it is commonly argued, implementation of ultra-high performance concrete turns out economical only when geometry is in sync with the principal stress lines. And while each structural case would produce a unique configuration of stresses, the fabrication of these non-repetitive and non-standard elements can possibly benefit from the concept of ice formwork: an automated process of fabrication capable of producing non-linear geometry and interwoven topology, does not produce any waste, and only requires a supply of electricity and tap water.
The research questions the linear progression from the design intention to its materialisation within current production workflows which determines a lack of feedback between the different stages of the process. This forces designers to consider materials as passive receivers of a previously generated ideal form stored in a digital model. As a consequence, design practices can only engage with a limited range of
How can we explore novel design opportunities extending the range of manufacturing processes available to designers?

The proposition is that we can achieve this combining robotic manufacturing methods together with different sensing strategies and machine learning techniques. The goal of the project is to establish a framework for training a fabrication system where the instrumental and material knowledge of skilled human craftsman is captured, transferred, augmented and finally integrated into an interface that makes this knowledge available to the designer. The project focuses specifically on timber subtractive manufacturing with different sets of non-standard tools to investigate, through fabrication case studies, the potential and limits of such approach. The collaboration with the two industry partners ROK and BIG plays a key role in the definition of the design to manufacturing workflow and its application within real-world projects, which goes from furniture, interior installations to small pavilions.

The main contribution of the research is the development of a series of training methods which combines the recording of skilled human experts performing subtractive operations coupled with autonomous robotic learning sessions. The sensor data, collected in datasets, are used to feed a machine learning procedure to extract correlations between the fabrication parameters and their material outcomes and use these to inform new robotic fabrication tasks with similar sets of tools and materials.

The results suggest the potential of machine-learning strategies for design to manufacturing applications as a way to explore novel design opportunities through materials and tools affordances. The potential to flexibly train the system to operate with different carving tools and wood species provides a prototypical framework to designers that want to customize their own production tools according to a specific design intentions or requirement.
Materialising Design

WORK PACKAGE #5
LED BY BOB SHEIL

Bob Sheil  Director of the Bartlett School of Architecture
The introduction of additive manufacturing in concrete construction challenges some of the principles that currently condition the use of concrete within the built environment; such as the dependence upon formwork and the tendency for standardization and simplification of architectural elements.

The process of placing concrete by deposition signifies a fundamental departure from conventional casting techniques. The formalisation of concrete-flow is no longer determined by the restraint and control provided by a predefined formwork, but by the self-supporting capacity of the material itself coupled with the path of deposition. This project investigates controlled deposition of concrete.
performance and the articulation of flow. The overall aim of the project is concerned with the possibility of varying the composition of the concrete used within a structure according to local performance requirements in order to achieve a more precise and optimal use of material resources. For this purpose, the notion of ‘material resolution’, as opposed to ‘geometric resolution’, is central to the work as it emphasises the syntheses between concrete properties and the choreography of flow.
This project investigates methods of lay-up patterns and precise fiber deployment for fabrication of Elastic Kinetic Facade Components. During the initial stages of the project the effects of controlled geometric variations and systematic stiffness differentiations have been carefully studied in a series of prototypes, the aim being to achieve higher movement efficiency, optimized cyclic performance.
The knowledge acquired via prototyping and data gathered through ongoing performance tests, was utilized in the next phase of the project. This involved up-scaling of the FlectoFolds, improving fiber placement, tackling shortcomings of the system in terms of digital control, resolving issues concerning the pneumatic actuation, enhancing the design of supporting elements and integrating all technologies in an architecturally detailed solution. In order to study and explore the limitations and possibilities that Elastic Kinetic Material Gradient Façade Systems have brought forward, a large scale demonstrator, consisting of 36 FlectoFold components has been designed, detailed, fabricated and installed as part of BauBionik Exhibition in Stuttgart (Germany) in October 2017. Apart from showcasing the technology in a public setting, the flectofold installation has been used to monitor kinetic performance and associated material fatigue in long-term cycles, assess application potential on complex and free-form architectural surfaces and analyse suitability as a shading or energy harvesting system.

In the next phase of the project, the exhibited demonstrator will be further used as a testing ground for monitoring, assessment and in-depth analysis of the kinetic performance of individual elements as well as the system as a whole. The collected data and gathered knowledge will inform the next steps in design, development and manufacturing of a range of Elastic Kinetic Architectural Envelopes. This project builds upon the research that is currently being pursued within the SFB-TRR 141: Biological Design and Integrative Structures - Analysis, Simulation and Implementation in Architecture.

The Fabrication of the Demonstrator was funded through the SFB-TRR 141 network.
This research investigates the use of Industrial modelling clay for additive manufacturing.

Clay plays an important role in automotive design when modelling ‘class-A’ surfaces. Design studios around the world use it to prototype vehicles at a 1:1 scale, combining several technologies: sculpting, CAD freeform surface modelling, 3D scanning and CNC machining.

This research has developed methods that enable modelling clays to be used for Additive Manufacturing (AM). This Liquid Deposition
of the material – which contains wax – allowing complex freeform surfaces to be printed quickly and efficiently – layer by layer. The research explores how this additive process can be integrated with CNC milling – giving rise to the term, ‘hybrid manufacturing’ – with a view to creating large-scale prototypes (i.e. 1:1 scale vehicles).

This technology promotes the creative freedom clay offers; at the same time, designers can now leverage the efficiency, geometric complexity and programming simplicity of additive processes.
Nowadays, new technologies in digital design and fabrication enable a larger body of possible geometries and manufacturing strategies. These technologies are mainly utilized to produce non-standard series of components from standardized materials, especially timber. This digital mass customization has been proven to be suitable for small scale installations. However, when applied to complex form buildings, the customized production approach results in a huge number of unique building elements that can be a real challenge when it comes to the optimization of assembly sequences.
The research aims to develop a framework for the optimization of assembly planning of mass customized timber construction elements. This requires an integrative approach combining design intentions, material knowledge, manufacturing techniques and assembly procedures, and at the same time involving all the interdependent actors in the building construction from the earliest design stages.

This approach suggests two inter-connected areas of focus: A local one, investigating how we can rethink design process to assure an efficient assembly procedure by rethinking the joints system and how these assembly procedures can be evaluated according to the desired parameters. The second focus is global and looks into the communication model between the actors during all the phases of design, especially the early stages and its effects on the overall design, manufacturing and assembly.

This will lead to set the theoretical and practical foundations of a new framework for complex assembly sequences: Assembly Information Modeling (AIM).
Sustainable construction techniques associated with traditional raw earth architecture are characterized by laborious manual tasks, where each clay mix is deposited in layers over a light formwork, such in the wattle and daub technique. Other materials such as concrete have explored more sustainable solutions, such as shotcrete or sprayed concrete over temporary or lost formwork (fabrics, inflatables or metal meshes). With the objective to reformulate the use of clay as a sustainable material, to reduce laborious tasks, to minimize the use of formwork materials, and to implement robotic fabrication processes, this research explores robotic techniques for digital fabrication of monolithic earthen shells.
This singular technique that we call “mudcrete”, is characterized by an innovative fabrication process of sequential spraying deposition of different natural raw clay mixes with drones over a temporary light formwork, and the use of UAV technology with embedded sensors to monitor the fabrication of the structure in progress. A case study features a 3m x 1m x 2m shell using a 2m - 8 helices drone, that follows a precise protocol for spraying different clay mixes in tanks filled with separate liquid or dry mixes to avoid blockage, with a refilling station and easily accessible charging points. Depositions of the different clay mixes are allowed by drone control through a combination of piloted and autonomous flights that are necessary to set up from the first flights and its associated spraying performances. Some preliminary tests indicate that initial trajectories can be coded, where parameters can be defined and refined, such as optimum distances to the surface, spraying angles, and particularly the speed, which can be integrated in the code so that artificial intelligence could allow the improvement of the technique on each flight sequence. Some extra considerations arise from the materiality, in terms of the proper adjustment of the clay mix at each step, the placement of reinforcement material (fibers or meshes), the drying time, the scanning for thermal or structural performance, or the actions required when a crack is detected in the shell. Additional improvements were highlighted by recent physical tests, such as using the drafts created by the drone’s helixes to help the drying process at each layer. Some conclusions are provided on how this technique is not only shaping new design and digital fabrication processes, but envisioning possible future applications and offering new scenarios for sustainable future habitats. (Text co-written with Maite Bravo)
PANEL DISCUSSIONS WITH EARLY STAGE RESEARCHERS
Communicating Design Dialogue
Communicating Design Dialogue

Jan Knippers: I have a question about the idea of validation... To my mind it is sounds something similar to summing precision and accuracy. I am wondering when you start the outset of your research, if you start with the idea of precision and the parameters of the software that you are using and develop what you are doing inside of that, would you then go onto validate in the sense of how accurate your results are compared to a real world scenario?

Dimitre: Validation for me comes in many forms, for example precision. Software has to be very precise, because otherwise you will have various bad things happening. Validation comes through working with software; decreasing bugs when it comes to usage numbers. It also comes through enthusiasm levels, which I know is a very qualitative benchmark. When you stream geometry around there is a big mess with floating point numbers with various technical aspects. There is a whole art for writing automated tests. For tests no, but the test use, yes.
Communicating Design Dialogue

**Tom:** In my particular case, the idea of prototyping is the de-validator. With the subject matter that I am working with, you actually have to make it and look at it to see if what was predicted in the simulation tool is actually working. And then validate it at an architectural scale. So in my case, I think the prototyping of it and the making of it is the way of validating the project.

**Zeynep:** For me its two-fold. On one hand, it is the integration of the process of this method to the early design stage and [discovering] how feasible it is to observe whether my approach is valid or not. [On the other hand] looking into the early design phase within the software and investigating what the most comfortable degree of accuracy is. Meaning I do not have to be 100% accurate, but what am I comfortable with in this early design phase? What my error rate can be, is more the question looking into the validation of what I’m developing.

**Helena:** On one hand there is the accuracy of the simulations as it is all quite experimental and if I try to benchmark it, it might not be that accurate (as long as it stands up and does not kill people I guess it’s fine). On the other hand, I think if the prototype is there, it is fine enough.

**Angelos:** There is always a trade off between how accurate you can be with simulation and also how quick or how easy it is to do simulations that you understand anything from at all. So as an architect, I prefer to understand something about the problem. Especially when we are talking about machine learning or about defining the problem for optimization, in most cases you will never be able to define the problem of optimization accurately enough, because there are too many parameters. So while you are defining the optimization problem you are learning about the problem as well, which is the most interesting.

**Jan:** I want to echo what you said because I think this was a very valuable comment, that some of you were talking about early design stages, where the parameters are not precisely defined, but using simulation softwares from engineering that does not distinguish between early and late stages in design. And this discussion about which method and which simulation tool is appropriate and which is a part of your storyline, no matter how this influences the methodology that you develope.

**Bob Sheil:** The architectural profession is about 200 years old and current students who are entering into architectural programs around the world this year, were all born in 1999, or 2000. And they would be hitting their careers in 2035 time. And I just wondered; one of the elephants in the room is this dance that has been going on for 200 years between architecture and engineering. Looking at
your work, what would you say to a room of first years now about how your research is redefining a discipline?

Tom: If you think of what we see now that was not there 200 years ago, it is obviously the digital and virtual model, typically we see the physical prototypes and then the virtual often treated as separate entities. And I think the integration of the two says that a material practice can also be a digital practice and vice versa. This is the biggest shift that I have seen since I started architecture until now, this interface between digital tools and that direct contact between stuff like scanning and modeling and simulation and the kind of physical aspects, being able to explore both in that tandem.

Dimitre: Focus on the process. In a way I think architects and designers have lost legitimacy. In order to actually gain that back and infuse it, you have to control of the process itself or be able to modulate that in a sense. The more you can diffuse yourself and allow yourself to lose control, to bring it back up and shape it. That is when you can have more influence on the object. This means fabrication on one end then specification on the other end, politics as well on the other end. Of course you have to bind this at some point. One of my lessons from working in the practice is that you need to always have the mental agility to take one step back and try to address the bigger picture. This comes with a better understanding of collaboration and control of the process itself.

Helena: I heard a very good lecture a few weeks ago from James Solly, who said that nowadays most of us are generalists, we are no longer defined as an architect, an engineer, or a computer scientist. A lot of people in the room do not end up what they studied to be. They end up in their inbetween spaces, between being in the box that it takes to be an architect, engineer, computer scientist, designer, fabricator, artists or whatever [title] you come up with. I think nowadays, it almost shifts in a way where you have to be multidisciplinary. Of course there have to be people who are very [well-versed] in their subjects, but it is also good to have generalists who cover different aspects. So to answer the question if some of us are either both or neither, I think most of us pushed into different aspects anyway.

Zeynep: When I started studying, it was back in 2001. Knowing 3D max was a really big thing. There has been a huge shift since then. And I think it is actually going to continue shifting as well. So we as architects, always pretended to be something else. Back then it was artists and theorists, and now it is shifting to be engineers, material scientists, programmers, and as you were also saying earlier, your son is learning python and I think he is 11 now. We are coming to an era where everybody has a certain knowledge on every topic. So I think we are coming to a more integrated phase where we can be more multidisciplinary and where we can have a common ground of communication, since this common sense of knowledge is always changing and is always increasing itself in different disciplines. The only thing I would suggest to students would be to get out of their comfort zone, because staying within the comfort zone of what they thought architecture was is a classical idea of what architecture is, and this will not bring us to a new level. I think everybody here is outside their comfort zone already and I think we have to encourage more people to do that.

Angelos: I do not think our times are that different because I think that we are constantly adapting to new technologies. So I think that an architect 200 years ago knew nothing about cement or steel glass, because people have to adapt and especially architectural education has to adapt. And as far as I am concerned, the place I am looking at putting the pebble is that we teach students how to understand the environmental effect of their actions in building, so that they make more responsible decisions, rather than getting them to be a bit more like engineers and a bit more like scientists. I hope that what we are doing will add to making them more informed in
what they are doing to the environment. That is what I would like to focus on.

Jonas Runberger: I think at the end of the day we will have more segmentation. If we look in the past, at other professions like medicine, a physician did everything, and now you have those domain experts. And probably will be the same here. So if you look at a master builder from the past who did everything, and actually slept on site and managed the work and knew everything that needed to be done in architecture, engineering and in the actual construction phase, now you have this segmentation. And now even in this architectural segment, you will start to see expert architects in specific domains. It can shape design analytics, it can be any kind of knowledge that is developed, you cannot handle everything.

Jan: Of course in the practice of design, we see this segmentation of more and more experts in the field, but at the end who is controlling the process? That is the question. Is it the politician, is it the economist, or is it the architect? Who is doing this? Do we hand over the responsibility to a bank manager or someone else?

Areti Markopoulou: I think the biggest problem of architects has always been the fact that we are building stuff that stays put for a long time. And we are building stuff that is defining the way we inhabit, they define the way that we communicate, they define the way that we are moving in a city, they define the way that we move information from one side to another. At the moment we are sure that we need to have a bigger impact, our architecture should be much more than just optimization, much more than advanced fabrication and robotic technologies. Our architecture should have a vision of really trying to change mentalities. How can we start, by the way that we are designing, and by the stuff that we are building, to be able to bring new modes of inhibition? The ones that we consider as architects in collaboration with the decision makers, that they are very close to us always, the ones that we decide can make our living modes and our societies better.

Silvan Oesterle: Maybe a critical remark from all of us is, in the long run, technology will always shape architecture. This is what we have seen happening in history. We are all technology enthusiasts for the digital turn. Technology has not actually changed outside of our bubble in the last 20 years. And this bubble is not that big yet. I actually see some worrisome trends which are reactionary when you look outside the bubble, which will revert to very traditional ways of conceiving architecture. I am wondering how aware are we of what is happening out there. I think you see it also happening in politics. I guess an anti-movement that exist in general in all the possibilities is digital technology. How it is invading our everyday life. Some people just close their eyes and turn away, and wish to be back in the old times. You see it in the Hymat discussion in Germany.
They are very backwards and partially politically dangerous. How do you experience that with your peers your age group? How do you see when you look outside the box? What do you see?

Dimitre: The first article I published when I finished my masters was called Algorithmical Abuse, in that article I was saying that this whole digital mumbo jumbo has created reactionaries. It basically split up the architectural scene into people like me at that time, thinking let’s make everything out of voronoi, and on the other hand people in the office that I worked with, who were more based in traditional techniques. I think there is value in both approaches, it is up to us to tease them out and merge them together. And the digital bubble is a bubble because we have not yet set a value for the 90% that is out there. Things that we digitally fabricate, or digitally design, this room here, is still more expensive. I think Zeynep ended her presentation wonderfully, so we have got the answer with the quote, if technology is the answer, then what is the bloody question? I think we are answering the wrong questions or we do not know what questions we are answering.

Tom: On one hand you have this fear, if you are on one side, automation is taking over, craftsmanship is dying out to be replaced by these soulless robots and machines, that there is no emotion. These sort of arguments that craftsmanship is going down and humanity is being replaced by automation and the digital. And then on the other hand you have silicon valley startups proposing that they can solve all of architecture’s problems with a new startup or a new app. I think the reality is somewhere in between. It’s very easy to be negative about these sorts of things. Or to be extremest about them and say it’s either completely bad or completely good. Where in reality I think you have to look at it more practically, as in, what is it that technology can actually achieve? Where are the possibilities? But not to get swept up and hold it up as a shining torch. I think you have to be critical of where you will use technologies and how you will use them, because it will not go away and we are not going to go back to hand drawing anytime soon. It is here to stay, and the question is not whether that is a bad thing, because I think it is just a reality, it is more of a question of how we are interfaced with it.

Alex Dubor: I think that the question we all have now is about where technology is going? There is a philosophy of movement of people who call themselves accelerationists, that is to embrace the fact that technology is moving [forward] and changing the way we are building and living in cities. It [just so] happens that big companies who use technology, want to make business out of this and they will push for it for economic reasons. The technology will arrive. We see this a lot around the topic of smart city; that technology holders sell as much as possible, and we will see technology evolving. We have to embrace the fact that this is happening, but not necessarily for the reason we would like to. We can actually embrace the fact that technology is rising and we can shift it toward making a better society and a better place to live in. So instead of thinking that we are in a bubble, maybe we are just a bit advanced [in time], trying to foresee where this can actually bring us and how we can slightly shift the technology, not only in productivity, but also in other aspects. So I still believe that effectively we are in a dream but hopefully we can come together, and not be against this economic point of view of technology.
Simulation for Design Dialogue

Panel Discussion with Early Stage Researchers led by Ulrika Karlsson
Ulrika Karlsson:
1. What is the role of simulation in your project at this stage?
2. What is your research question?
3. And what will you exhibit, how will you exhibit something that is not physical?

Giulio: My research question reflects on what I think of the role of simulation is. There is a strong technical core of my research that deals with if it is possible to integrate real world fabrication data to our design tool manufacturing workflows to improve accuracy of different fabrication tasks, especially working with non standard tools. And how this could be used in design practices to take better informed design decisions to allow interaction with the fabrication as a moment of exploration. Dealing with material behaviours and tool performances as design drivers rather than simple materialisation.

Giulio: I think the exhibition is going to be dependent on what the outcome of my collaboration with the two industry partners would be. With ROK, it is much more defined, we are working on a furniture
Copenhagen for the two months of the exhibition to have it as the main exhibition. It would also be interesting to see what the final output of the collaboration with BIG will be. I would definitely like to bring into the exhibition a proof of concept as the method I have been developing into real world projects.

Vasily: Regarding the simulation, I think within my research I am constructing an opportunity to implement simulation as creative actor in the design process. Therefore I think while designing the final prototypes I will show more of the integration of simulation in the design process. My goal is to achieve this in the collaboration with Buro Happold.

In the light of what has been discussed during the presentation, I think my plan now is to find a design that would be functional or at least a good illustration of the possibility what the fabrication process can do, then I would like to scale it up to be more convincing.

I have already formulated three questions for the research along with the understanding of the critique regarding reinforcement. I am developing a technology that will cast concrete in ice, that in my opinion will allow a more sustainable fabrication process for the industry, especially in light of the new material, high performance concrete. The first question is this material harden in ice, and therefore inherit the geometry from ice? Second, can ice be precisely machined? And third, what does this technological set up cause in terms of economy? I am arriving to a conclusion with the final question.

James: To be honest I think the role of simulation in my work is relatively self explanatory, everything I talk about is some form of simulation. Actually this whole process comes at attacking the problem of a complex system from the point of view of what tools might enable people to understand it better without just testing. Something I see in engineering that is changing, is a long time ago when people were first starting to understand the buckling of steel, the whole thing was done through experimentation. And [therefore] a lot of the encoded behaviour in design software now, [such as] buckling curves, are based, to a degree, on science equations derived from testing. We have just forgotten that. So I find it quite interesting seeing some of the problems that the others are looking at in the program, where you actually say, how do we encode experimentation as a form of simulation? So much of what underlies simulation is forgotten, but for me now I work on the more standard, bulk simulation.

In terms of my research question, I think something I really phrased in terms of what this can do for designers. Some of the questions that were asked today about do I really need to frame this in terms of is
Simulation for Design Dialogue

this a tool for designers? I am not sure yet, I think it would be interesting to explore that a little further, and actually maybe I can put something together that at least presents it as a tool for not necessarily designers, but for anyone to use as a way of understanding a process. I am trying to grapple with how to describe using this tool as a way to understand a process that you might want to use in a variety of ways. My research question of how I can design this is still valid.

I honestly have not fully wrapped my head around what I will present, I think the clear parts include making a few more speculations of what some sort of optimized beam might look like. Maybe it will be a bit less flat and a bit more 3D. Apart from that, I feel like I did my demonstrating. I will make a few small prototypes, however my intention is not to make another pavilion, maybe there is a way of representing these digital tools in a way that people can play with them there. It would be exciting for me to both show in the exhibition, not only what you can achieve, but also allowing people to play with it. Perhaps as I move into the more simulation derived area of the research, it would be fun to let people play with that instead of just looking at something that someone else made.

Ulrika: One thing is how you are thinking about the exhibition and what you would like to exhibit, but another thing is to also ask what do you want the exhibition piece to do? What do you want the exhibition piece to do? For you and for some kind of audience.

Efílen: For me simulation is a digital experiment, I try to compliment the physical and the digital, and verify one with the other. This was my initial goal and is what I am doing. I have so far focused more on the physical than the digital, but I am planning to have more digital in the following months.

My research question is: How can we create large scale adaptive shape shifting structures?

My aim is to exhibit a final demonstrator, I will try to collaborate with a second industrial partner for a real case scenario, I would like to exhibit what we make. I want it to be a shape shifting structure, as developed as possible.

Paul: I have been dealing with simulation at the beginning, and far away from it for a while now, I do not think I am doing simulation anymore, unless you can say building implicit relationship between virtual objects is a simulation. However I think in this context I am far from any material experiments.

My research question be regarding the ideal AC platform to allow different users to build and assemble their objects. If I follow
Ulrika: So when I asked about what you want the exhibition to do, I was thinking about not only exhibiting something that performs but what do you want to learn? What do you want to get back from it, apart from making something work? And also how do you want the visitor to interact with it? How should they engage with your project?

Jonas: I really just want to reflect on a meeting we had with the industry partners, the time schedule in all these hours is different coming to the concluding part of the phd, but one thing that came up that I will bring forward later on is as you move more into the conclusion of your phd, if we disregard exhibitions, books and everything else, right now do you potentially see a shifting role for the industry partners in the support? I mean besides doing the experiments you have done now and then maybe the exchange of knowledge as one, do you have a reflection in the very late stage of your work, which is in some time in the future, how we as industry partners can contribute and engage, and keep the engagement that we have now?

James: I am not so sure if the relationship is going to change that much. As I gain more information about what I see the phd being, which actually has come about through conversations with industry partners, and with academic professors. I would say as I gain more clarity, the questions and the discussions shift, but the relationship for me has been on one hand to do with fabrication, that I think in the run up to an exhibition, is clear. Maybe following the exhibition, it will be more about continuing to integrate some of the proposals into an ongoing workflow so that this work is not lost forever. Maybe that is more what you mean. I think I would like to see if there is a way to leave something behind. In terms of the other side of things, I hope it is the same for everyone but we get some general support, I find that within all of our industry partners, there is a real range of people. There is not just one company you are talking to. And a huge range of skill sets, from critically reviewing what you are talking about, pointing out if you are not making sense, or trying to steer you in some sort of direction in your own thought process. I hope that this all continues as we go forward, perhaps we would just be asking more specific questions.

Mark Bury: Maybe it could be quite simple in that, as you hertle toward a conclusion, the industry partner has to clarify what was the question that they wanted to address at the beginning, and did it change through the work? And the candidates explain unequivocally, the link between the industry partner and their achievements. So that neither the industry partner goes away thinking, “well that was a waste of time”, and the candidate does not go away thinking “I did not need the industry partner”. So that could be a little test.

Efilena: For me when I started, my topic was quite different than the question that I am addressing now. I started much later than the rest, and was advised “to go to Blumer Lehmann, my start collaborating from the beginning. And formulate my exact research question according to the needs that they have”. That was the initial intention for all of us. But I think that because we are all different and the person who was here before me was different, and in any case, we interpret things differently, I would say that the initial intention changed a lot. On the other hand, it was always a back and forth with my industry partner, what do they want? What do I want? How can we find this balance? This was extremely challenging. In my case it worked out quite satisfactory. This has been a constant relation, and I hope that this continues, but also when the project continues, because the aim of innochain is to prepare young professionals in a specialised market. For example we had a meeting with Martin to start talking...
about what we want to do when I finish. So it has not just been about the contribution throughout but also, to gain an understanding of what is happening now in industry. Also to help us to position ourselves in the market. I think this would be valuable for all of us if this thing is ongoing and we also see your opinions. What do you think there is a need for and what would be suitable to do from your perspective?

James: We have had various industry partner changes throughout the program, that have been very good collaborations. We are doing this program once, I wonder if for the industry partners there is a wider question about how this collaboration with us has been. And whether you would do it again with another person? I hear all the time that there have been several PhDs going through offices and I know that across our partners some have had many PhDs and for some this is the first one. I wonder if there is an internal feedback process of how well this particular one went. InnoChain has a particular slant compared to a highly engineering focused research with no design, and I wonder at the end, how well it went and would you do it again? Would you choose a different route? What would you change next time you are invited to a startup?

Martin Antemann: The time to reflect is at the end, when there are results, therefore I do not want to give a statement at the moment. What I can say is that we want to bring things to a close and finalise within our written contract period. This is what is asked from the industry. We are not saying, we have done something, we have played around here and there, we have things to see. Rather more to focus on the specific topics, and be more concrete, and to be structured with time and content.

Al Fisher: To echo some of the comments we had in our industry partner discussion, I think we can safely say we are on similar pages, so that is really good. It is something we will feedback in our discussions, and make sure we are all aiming for the same target. We

There was a very positive mood in the discussions this morning that actually everybody wants to work to make sure that we can complete this phase of the process. Equally you nodded to further waves of InnoChain that maybe the people sitting on the stage would not necessarily be as actively involved, but others would be, I am hoping that there is a lot of learning that can be done from this. It is an experiment for all parties. We would all be wanting there to be some good mechanisms for active feedback in every direction.

Sam Wilkinson: For some of us it is also a new experience, the training process that you are going through is giong to put you in the position that we are in now, so that in three years time you will be sitting here on this side of the equation. I think it has been good training for you in that perspective to see what it is like.

Jonas: On this notion, that many of us have doctorates and phds, I think what is worth mentioning is the network. I think without InnoChain, I would be talking to one phd, so there is a big difference in these events, it makes a big difference. The one small reflection is that actually in a way that becomes personal, me personally being able to be within this context to meet all of you, my colleagues don’t. really get that back in the practice. So I am trying to talk a lot about what it means, while they of course, are talking to our resource, in another way, so it is a tricky thing to handle that I cannot bring the practice here.
Materialising Design Dialogue

Panel Discussion with Early Stage Researchers led by Bob Sheil
Materialising Design

Bob Shiel: Who is your research for?

Saman: what the research has led me to do is a plastic hinge, this can find its life in different industries, my intention is to contribute to the construction industry for architecture.

Bob Shiel: What of your industry partners problems are you trying solve?

Saman: At the beginning of the project I said, “it would be really cool if we have kinetic responsive facades”, and I ended up working on a hinge. Now looking back, I think showcasing the potential, would be not solving, but catering a potential with this endeavor. In technical terms there are many advantages, the elastic stored energy, the lightness, the reducing mechanical energy. I circle around the same issues, we are moving towards an environment where everything is interactive and there is an extreme amount of user control.

Bob: One of the baseline problems in industry is believing in the proposition, your research makes the proposition of this family
of ideas to have a greater possibility to become realised. You are increasing the accessibility of the research that challenges the mayfairs that would dismiss the ideas in the first place. The word no comes in early on with complexity in the industry. You are trying to solve the idea of saying no.

Bob: What of your industry partners problems are you trying solve?

Stephanie: There has been a tone in recent years that this seems to be something new but humans have been materialising design, it is actually one of the oldest thoughts. Finding some alternatives to the major concrete industry and to revisit techniques that are already well developed by slightly changing some parameters to offer more sustainable versions. As well to work on the affordability of the construction industry to reduce the cost.

Bob: How do you measure if you have achieved that or not?

Stephanie: Part of the research will aim at answering this question by measuring how much energy I need to create a certain structure. How much CO2 is emitted by normal construction in concrete and trying to compare this between shortcrete and the technique I am trying to implement, with the help of engineers.

Jane Bury: The thing is you could measure that before you start the research. Embodied energy is very theoretical. Don’t you want a problem that your research actually addresses directly? Is the problem more: Can you do it [in reality]?

Stephanie: Yes
Bob: What will be your original contribution to knowledge?

Stephanie: To be the first example of revisiting traditional methods with new robotic techniques and introduce it into the industrial chain.

Bob: I felt [your research] was missing a really full analysis of the spraying technique, ie: speed, direction and distance of the trajectory, or the heat of the surface it was landing on. It strikes me if that is your interest in original contribution, one has to be very clear as to how one measures the gains.

Bob: Arthur, lots of people admired the intense technological investigation but some people were left unclear about the direction is going in, [how is] the automotive industry coming back to inform the architecture industry? Who is your research for, and what is the problem in the architecture industry that you are solving?

Arthur: When I first started this investigation I wasn’t trying to resolve
any particular pressing need, I was just responding and reacting to the process and what it was trying to do. It so happened that I found a result in automotive design and I went off for that application, I think that is a perfectly rational and reasonable way to proceed. I am not trying to resolve any problem within the construction industry. The original contribution to knowledge would be that the material was not thought of as a material for additive manufacturing before. I think that could open up a lot of possibilities for automobile design and how that can interface with the really rich and exciting suite of technologies that they are currently using.

The feedback I have gotten from the auto industry in terms of what problems it is solving, are the basic issues of automating the manual work involved in armature preparation. We are talking about the process, which currently only has subtractive capabilities. I very much hope I will have the opportunity to work with the automotive industry and how to serve that design process.

Bob: I thought today really exposed the fact that you are not an architect, I don’t mean this negatively, I think that’s where the elephant in the room is with your work, that you are a fine artist coming into a world of production, looking at material in a very specific process and then reaching out to an industry through its practice in modeling. I think there are very clear lines that transfer across to the architectural practice and translates to the industry, but perhaps since you haven’t gone through the same journey that other people here have you cannot see them… We have some work to do there in returning to the conversation with Fosters and seeing to what extent they are engaged in technology transfer back into architectural design.

There was this moment where the material itself, which is neither clay nor wax, it’s this mysterious proprietary trade secret product, but you have analysed its behaviour in relation to processes in a completely novel way. Whereas the original contribution to see at the moment lying in that very narrow seam of taking a material into a new process and demonstrating it can be used in that process like no other material.

Arthur: Yes if we are being very reductive, that would be the core contribution.

Bob: Perhaps then as a result of today a review of the state of the art was required to make that point. I felt as if you have actually broken a technical challenge, it was not completely revealed in comparison to other practices that have been adopted right now.

Bob: Helena, the question of who is the research for, seems to hover between the world of the concrete industry, the highly technical side of things, which is a daunting challenge considering its size, power and accessibility to technologies that are beyond your reach, and the architectural background. Are there any further reflection on the challenges that you have to set yourself and the elements that need to be demystified for architects?

Helena: From my understanding concrete is a mysterious material for most architects. What I am hoping to achieve is a working methodology in which one can be informed by this material behaviour in this material state towards a new tectonic based on the printing process. The way that concrete is used, [as it] is a very abstract material for architects, we work with it based on its mechanical properties rather than its fluid properties… and how they can inform the design process.

Bob: Ayoub you are in a very different place than everyone, very brave for starting this when everyone else is ahead. Though there are some advantages to that, where you can look at the other 14 ESRs and see where there is a gap in the market, there is something here that nobody else is looking at. What do you feel your contribution will be to the innochain network?
Ayoub: I am at the point where I am trying to draft the points I will try adress in the research. I am a little bit familiar with the projects, and have been looking at other projects, there are some points where my research would overlap with an ongoing research because they all looking at the digital chain and add their piece to the puzzle. So I am looking at how I can respond to certain needs in the market, and if there is a possibility to collaborate with ongoing research I would be interested.

Mark Bury: It’s a comment that applies to not necessarily everybody but it’s a question of have you been hungry enough to look for fresh resources when you come to a blind alley? I think if you come to a blind alley there is a temptation to make that the inquiry itself whereas sometimes you need to step out and go into completely a new. Does anybody feel that they are in that situation? Because if you are we can help deal with that.

Helena: a blind alley in terms of having asked the wrong research question?

Mark: I don’t think there is such a thing as asking the wrong research question but there is such a thing as asking a research question that is not getting anywhere fast enough. In Australia the phd is framed as research training, so basically it is research at the highest level that is supervised; when you have got your phd you can do research at the highest level unsupervised. It’s about learning the techniques as much as it is about solving the world’s big issues, and one of the opportunities is to learn when progress is not being made fast enough or when something is obstructing you, what can you do about it? One of the things you can do is to continue poking it with a sharp stick and it actually might scream out an answer but there is also a risk that nothing answers. So then you have to think about what you do if nothing happens? Then who do you reach out to? It seems to me the InnoChain is a great place for having these sessions, not just on camera, but off camera too. And to compare notes and strategies.

Jane: Necessity is the mother invention. I was thinking about your resistance to thinking about the transfer of knowledge from automotive to construction. And then I thought that in the moment in digital fabrication, we are working back in Australia, with an auto patent maker. That’s what they started out as. Now because we don’t have an auto industry anymore they have realised they can make incredibly complex things from all sorts of materials and all sorts of shapes and where else is there a market for that? Of course, because they are loony architects and artists, and now they are the go to people to do anything complicated in the industry. So it’s almost like in many of these cases, that the need is not urgent enough, or where is the urgent need? So maybe you just need to bully your industry partner to tease out where the need
is that you should address? Because it’s quite difficult to do it the other way around; to find the answer and then invent the problem.

Steven: I am sufficiently old to never have gotten over the joy of Googling things. I wonder how many of you have actually googled the problem that you think you have in every conceivable mode of language just to see what comes up?

Saman: I have to admit I never wrote the main research question into google but I have done it so often for so many topics like state of the art, or different fabrication methods, but I have never directly shot the research question into Google. It’s a good suggestion.

Arthur: Yeah, I have done many Google searches on my project, which led me to … When I was trying to research the rurality of the modeling clays. I found information in all sorts of unexpected sources, because the materials have this relation to plasticine, so I was uncovering information about the rurality of plasticine as an analog material for rock formation and all sorts of geological processes. You end up uncovering information in all sorts of places. I found the freefab project, but my reaction was to seek them out and suggest that we could work together in some ways. So the internet is a wonderful thing.

Helena: I haven’t really Googled my research question.

Stephanie: I actually Google a lot, at the beginning I was not sure if it already existed. Then I found out that there are loads of spray formations on light structure fabrication techniques that already [Work]. I thought I was crazy but then I found out that there has been 100 years of history in doing this.

Ayoub: I have to admit that all what I am doing now is googling. I would say I am finding fascinating results, maybe not necessarily related to what I want to do but they are informing the direction I want to go.

Steven: Well it’s just that I started to Google heavy duty plastic hinges, and an awful lot of very strange things came up that I did not see on the wall in your presentation. And I was just thinking that architecture and the automobile design might yield a lot for you too.

Saman: I have to say I didn’t include a lot of this research, some of the earlier prototypes that were made were taken to BMW in Munich, once in 6 months they have a research review where they gather information. They contacted us, came to take my prototype, and have never said anything since. I know they intend to use this for
Materialising Design

parts of the ventilation in the automotive industry. The small scale application seems to be more appropriate for this, once I found this trajectory I stopped Googling as much as relying on the known sources.

Bob: I’d like to open up more discussion about the research industry partners and where that conversation is going for each of you. Arthur, in respect of how the questions have shifted from where they were at the beginning and how they are today, how are the industry partners collaborating and engaging with you about taking the research as you have it in the moment into a field that would be applied quite soon?

Arthur: I think throughout my project I have had a fluid relationship with the Industry Partner who have changed quite a lot, some of them circumstantial. I have also had some fruitful interactions with collaborators and participants on more specific topics that feed back into the research. It is great to get that kind of interaction.

Saman: It is very interesting because before I came, I knew there would be two ways to approach this question, one would be that my industry partner did not have the tool I needed so I decided to not work with them and found a new one. The other one is for example with S.Form, who has long years of hands-on experience with FRP. He does not have the fancy tools that C-con has because they work with Airbus and BMW, who can afford to have multi million euro machines. The interesting thing is that he is like an encyclopedia. I have visited him on many occasions but we have never used S.Form as it was intended for the fabrication facilities. He took trips with me to Munich to a company that produces elastomers for example, that has lead to another collaboration. The same with Llulia Linhard; he went to the exhibition, came [to me] and said that “we are building a project in Hungary, and they want [your prototypes], they want a visibility study by the end of January”. I said, “but it is breaking, it can only do 2000 cycles to be honest”. This lead to discussions about further development, for me it has been very dynamic and fluid where everybody has been helpful and referential in helping me find my way easier.

Bob: What I want to get to here is the role of the exhibition in eight months time. We have had this talk today about materializing design, there are pieces in the gallery, and a big part of me would like to see it here on the table with people picking it up talking about it, because what that opens up is a different channel for conversation that addresses the literacy of the audience in a different way. I remember a conversation between Robert Aish and Nick Caliocott after the lecture Nick and I gave about 5502. Robert, because of his knowledge of ship building, came up with a question that he could only have come up with by seeing an image of what was made and recognized that there was a geometry in the physical artifact that couldn’t have been made if it was through software as a simple act. It had to have been made as a semi analog process. So industry has a literacy to it, your industry partners have a literacy to them, that is different to the visual literacy of the architect or designer. So I just wonder for each of you, if you could talk about where you see the role of the exhibition being for you in eight months time and thinking about Mark and Jane’s comments about how can we up the game in this time? What is the role or the point of the exhibition for each of your research beyond it being a showcase of work. It’s a different way of communicating, a different way prepis, a different place in the whole innochain production.

Stephanie: what are your goals, again thinking about who your audience would be and what sort of questions your piece will raise?

Stephanie: I would hope that we manage to exhibit the process, different kinds of depositions, spray, textures, failure experiments, different surfaces of inflatables, kind of a catalog of the journey. ideally the process, a glimpse of the new technology that we are
Materialising Design

talking about, apart from the samples I would like to have a
demonstration that would be a prototype of the structure showing a
step of what the research has reached.

Bob: Do you have a sense of what that thing would be physically? Is
it a vault in Copenhagen? Or is that just in Barcelona?

Stephanie: Many skins of the inflatable plastic with many different
texturing according to the spraying device and the material that is
being sprayed, and a live demonstration of a large structure, of the
tool being developed.

Saman: I will probably not be shipping the whole prototype to
Copenhagen. Firstly, I have learned so much from making the
demonstrator, from where it has been successful and also from
the failure, being material or support system or control, and all of
that has provided a finer solution on the problem, and I would like
to spend the time, since I have not yet secured any sort of funding
for post InnoChain, but I need to wrap up the story in the year or
year and half after, I would like to focus on the problems rather
than making, because I realized I have spent an incredible amount
of money, a lot of which has been spent on logistical issues just to
make it happen. This only means I would like to present maybe one
or three flectofolds that function really showcase the potential, so
that many the building industry or research institutes would like to
pick up on it to make a structure from. A smaller piece, definitely an
improvement on lessons learned.

Bob: It would be very nice to see some of the pieces there otherwise
it would be a risk of drifting into another work package, where it
starts to talk about simulation and communication rather than
materialisation. The physical stuff there as evidence of failure, and
how their failures have been measured strike me as significant.

Arthur: I cannot give you an exact answer, but it depends on a few

things. For a long time I have wanted to exhibit an actual installation
of the process functioning that would provide more of an insight
of what is actually going on rather than merely static objects. If
Copenhagen provides the opportunity to do that I think it would be
interesting to set up a full test regan. Make some objects there.

Helena: I really wanted to exhibit a family of performers, which is
showing an expanded material library for the deposition process.

Bob: Okay that’s very clear, you have eight months to do that,
how many pieces will it involve, who is going to help you deliver
them, picking up on the questions made earlier. You are going to
commission pieces to be made, is that how it will work?

Helena: The specific recipes I will develop with the research institute,
but I see the exhibition as a more starting point for my collaboration
with White, because for me that is projecting quite far in the future
from the scale that I am working.

Bob: Just thinking about the point made earlier about curing, if you
can’t cure a piece of concrete today, it will still be curing in September.
You can play on time here.

Robert: This exhibition sounds really important, and the first thing is,
what’s the intended audience? Is it going to be a public exhibition?
Are we going to invite the Institute of Danish Architects to come
see this? Or I guess the EU representatives will be there, but I was
thinking that there are different elements that you might want to
think about. One is the concept, or the explanation of the concept,
than test cases like dropping different kinds of materials on different
kinds of surfaces so people can see visually some aspect of the
exploration that you’d have gone through. And then something full
size always grabs attention, even a slice through cross section. And
then maybe a visual of the technique, if it was used in the future,
it can be an illustration that points to the function. So if you had
that spectrum going from concept, process, research, full scale, and some illustration of a big building that used this then you would have a full spectrum of your ideas. Then it would be a very effective communication to the audience.

**Bob:** Are each of you charged with the challenge of coming up with a design? As well as the design question and research, in some cases, the design might not be where the value of the question could be, the design is the place which the question is played out on... The investment you’ve already made can be played out much more quickly by abandoning the dilemma of having to be the designer, as well as the researcher of the process, as well as everything else.

**Ayoub:** In contrast with my colleagues, where the exhibition is an opportunity to show their final outcome, or part of it at least, I see this opportunity as an important milestone. First I would like to define more precisely the research questions where I can have initial results. I can speculate and say by then I should have two prototypes, one software and a potential application of it. **Bob:** To touch on Robert’s question, the best audience that can come in is people with some knowledge of the industry but no knowledge on the research and they’re hit with this in that space directly, and making a judgement on its value based on what you bring into that space and how it tries to communicate with them and their knowledge. So industry and professional specialists.
03
INDUSTRY PARTNERS INTERVIEWS
Industry Partners

Video Interviews with Industrial Partners for Innochain Second Year Colloquium

For the Innochain Second year colloquium at the COAC of Barcelona organized by Mathilde Marengo, Areti Markopoulou Maria Comiche and Lili Tayefi, researchers were invited to run some interviews with their industrial partners in an official video format.

It has been for both researchers and industry partners members a great opportunity to dig dipper into the collaborations taking place but as well some feedback on the overall innochain network emerged from the conversations which constitutes some precious material archived in a uniform format of the 4 years Marie Curie (first one in architecture) funding.

The interviews helped tracing clear paths in the next steps of each ESR collaboration with their industrial partner which resulted in many different options ranging from scientific advice to ful involvement in some under construction projects.
Moritz Dorstelmann: [FibR is a] Specialist company in computational design and robotic fabrication of filament lightweight structures.

I’ve been developing these technologies over the last years at Stuttgart. We are teaching at the technical university of Munich, and mainly running our business bringing nanotechnology into the market.

What does FibR do?

FibR offers computational design and robotic fabrication technology for lightweight structures made from fibre composites, which are an incredibly versatile material that enable novel design and construction repertoire in various fields. [This is what we offer] to our clients from various fields [with whom we] cooperate on construction and design projects.

As FibR stems from previous academic research projects, can you share some thoughts on differences
between Industry and Academia?

I wouldn’t contrast those two so much, academia and industry, but I think as a company building on rare and cutting edge technologies we are very much at the forefront of development. We do a lot of inhouse research as well, we have a lot of collaborations with various institutes, so we work hand in hand with academia. With teaching at Munich university, I am also still rooted in academia. Going into business and industry allows you to implement things that you’ve developed in the last years in a much larger scale, really bringing it into application in architecture, design, construction, and product design. To not only see how those technologies worth investigating by themselves as basic research but to really tease out, with various partners from industry, design agencies and architectural offices, how it can play out in a larger field. And actually see the things come to life that we have developed as a small seed at an academic route.

How does FibR see the role of Industry to Academia Collaboration?

In industry you need to work a lot on projects, which means that there are very interesting projects and clients that allow for a lot of innovation, and are asking for the innovation. This innovation needs to be developed very closely with the guidelines of those projects. And I think in Academia you can allow basic bottom-up research, which is really important because that might bring a very unexpected result that later finds a specific application but is not bound to such a streamline development.

Does FibR see a relevance to the work of ESR08, James Solly, on “Virtual Prototyping of FRP”?

Particularly now with the collaboration we have with James at ITKE is beneficial for our company because there are methods being investigated that currently we wouldn’t spend the time doing in depth. We also would not have the inhouse engineering at the moment. Is of immediate relevance. What we are doing it’s great to work from two sides toward the same front forward of implementing those kinds of structures actually and bringing them into application. There is still a lot of work to be done on multiple fronts and one of them is for example the simulation and design algorithms allowing us to understand the digital prototyping of these composite structures a little bit more in depth, which in the long run can also save a lot of money in industry. If you can run a beforehand simulation, anticipating certain failures that you would maybe find out at a prototyping phase [otherwise], it is already beneficial in the early design stage.

Both FibR and ESR8 work on lattice composites. What is it that clients find interesting about these forms?

Clients are on the one hand intrigued by the design qualities of our structures and at the same time very convinced by the lightness, material efficiency, modularity, with all the benefits of transportation, handling time, and installation. This can play out as a huge benefit in a lot of industries, whether its products, interiors, fair stands, or what is standing lightweight constructions. We have been approached during early academic explorations by various people from various fields who saw a lot of potential. Then there was also one reason that sparked the idea of starting it as a commercial endeavor, because there really seems to be the market for these structures, and we keep getting approached by various approached by various people who are interested in using this in structures, facades, interiors, and furniture. The interesting thing is, that it is a very particular service that you offer, but it is applicable on a wide scale of [uses]. It is offering solutions for [many] problems, similar problems in different realms.

I What are the largest problems in realising composite lattice structures for architecture?

Larger hertles can sometimes be on the material side but also on
the legislation side. The building industry slowly adopting novel processes, and it takes a while until this becomes accepted as mainstream construction method. It’s important to look at it from an academic point of view and develop basic guidelines for construction composites, so that other engineers can take in hand and understand better what they are dealing with. For example, inflammability, in composites. We have several flame retard composites that we are working on. We are very interested in using a material other than egg composites, different kind of ceramic matrices which are not that flammable. Such as they have a really broader application scenario in the building industry as customized rebar formwork, where the fibre would be very much protected by concrete. On the other hand, that application is for the fibre so you need a very chemical resistant fibre induced application. What we have seen in our academic development in the last years has been only a very small showcase of the technology, there is a much wider applicability in the construction we can explore that will take time. Those are the hurdles, going step by step, but that is why we want to be at the forefront. We want to be part of the development, and just keep going along that development and be one of the pushing forces.

What do you find exciting for the future of FibR?

It is an exciting time to start a company with nanotechnologies [that] also find a more broad application scenario. [As well as] clients who are interested in it and are specifically asking for it. What would be interesting to see, is to go further with the exploration of the very expressive structures. And at the same time, see more basic applications. As we mentioned before the concrete rebar could become a great product in the building industry. We are working at the intersection of design, making, and development. So Clients often approach us at very early phases and want to know what kind of novelty in their design exploration we can offer them. That is something that I am, as an architect, looking forward to; being a part of various exciting projects, being approached by different challenges, and doing what we developed in the last years in the academic realm. When working together with clients, to prototyping, development, and larger scale implementation, in a very integrated teamwork process. This methodology break up the standard way of how this industry works with the architect, the engineer, and the fabrication company. I think those things are now intertwined. And that is where our company sees its position, contributing on all facades of the project.
Sam Wilkinson: Foster and Partners is an integrated design practice based in London. There are 12 people based in the campus here. We are based around a series of design studios with a number of support groups, each offering a different area of expertise relating to the design process, such as visual communication or urban design, industrial design. The group that we all work in is the specialist modeling group, which there is about 25 of us within. Each of us is an expert in our own field, so we have people that have expertise in aerodynamics, fabrication, machine learning, and bending active tensile structures. The thing that brings everyone together in the group is that we all have an interest in research, which ties in quite nicely with the PhD collaborations that we have, particularly with InnoChain. [We are] working with four of the Early Stage Researchers (ESR): James, Evy, Arthur, and Angelos. InnoChain was funded by the European Union, and the format of InnoChain, is in itself kind of an experiment for a way of bringing together the industry and academia to do research. The ESRs are the guinea pigs in this experiment, it’s
Foster and Partners

selling a blueprint for how research could be conducted in the future. Maybe universities alone are not the best mechanism for doing research applicable for practice, and vice versa. It is trying to strike a balance between the two, which does not always work easily. But I think at the end the ESRs will have sort of taken something from it that you would not have gotten from another PhD program.

What benefits do you see from collaboration between industry and academia?

Richard Maddock: We have had many PHD candidates who have been within our group and have helped progress research projects further, we have taken the output of those research projects and put them into actual projects. As a practice, we work on a wide variety of typologies and buildings that are of varying scale, from door handles to cities. To be at the forefront of what is new and innovative, we need to be across from what is happening in academia.

Miriam Dall’Igna: A common interest of exploring the novel is when we enter the office, is most certainly that we are going to invent or design something that has never been done before. This is common grounds with research and innovation.

Do you do in-house research that is not specifically linked to a live project?

Jan Dierchx: We believe, as a company, to use research to break new grounds in architecture and the built environment. We have one of the largest research teams for an architectural practice in the world.

What do you think about open research and the sharing of results?

Reinier Zeldenrust: There is definitely a trend towards open access journals. I think there is also a trend in sharing more and more findings in a less formal way. In computer science for example, you see a lot of people sharing their research findings in youtube videos that are three minutes long and easy to access, easy to share. And I think there is an increasing trend to publicising the scripts and the methods that were used, in an open source format, that is usable in practice, and makes it easy to experiment with.

Do you believe in disrupting traditional architectural workflows through research?

Octavian Gheorghiu: I think Foster and Partners has always tried to be a disruptor in the field. Even in the humble beginnings of the practice, research was part of the goals. Every project opened up a possibility of looking into a new technique or design, which led to innovations. Norman was asked by Bucky Fuller: “how much are you building way, and that question by Bucky Fuller was always something that struck him. If you think about it, most of the architectur at spaces are created with the least amount of materials, and that goal has always been pushed through research and innovation. You get to the latest structures that we have made, which are incredible in the amount of span they reach and so on. And that kind of work cannot be achieved without the research to actually make it happen.

Do you see a benefit in using Carbon Fibre in architecture and is it already being used on projects?

Miriam: It finds its application when you strike a balance between the weight of the structures and how much you can load a particular structure. Also the flexibility of geometry that carbon fibre brings, application and relevance in the projects here at Fosters.

Richard: We have looked at many projects that require a light weight structure, this notion of trying to minimize material use, There is a design goal of having lightweight things. Many of the projects we work on from airports to stadia museums, the requirements for a
Foster and Partners

lightweight, long span structure are strong. Many of these successful projects we have done in the past have involved innovations and research in lightweight and long span structures. To try and push that envelop learn about new materials, and how they can be used in the future is something that we need to do as a practice to keep at the forefront of architecture.

Do you see a potential benefit of additive manufacturing for architecture?

Sam: We have had long ongoing collaboration with Loughborough university looking into concrete printing. And are currently involved with a consortium looking into additive and subtractive metal printing of pieces up to 6 meter scale. There is still a question, I think, in the industry of how to design with additive manufacturing, that no one has really answered yet, us included. This is a very broad research question: ‘you have a new technology, how do you use it for its best effect? This overlaps with the works of Arthur, and James, with their robotic fabrication, how do you design with these new technologies?

How is simulation and specifically CFD used to drive the performance of projects?

Andy Acred: CFD is becoming a very important tool in design, due to its power not just for the physical aspects, but also for visualization of airflow. At Foster and Partners we use CFD for everything from small scale design, for ventilation openings to much larger scales for optimizing windows for a city, in order to minimize the effect of air pollution.

Reinier: We get involved quite early in the design process where there might only be a few lines of sketches on paper. What we do then is use our experience, informed by simulation, to guide the opening to make sure that we can get something that has a high performance from the start.

How do you communicate simulation results to the design groups and/or clients?

Andy: We have an inhouse team of expert, who are very much at the forefront of this modeling technique, CFD is continuously developing as a design tool. And our team interface with research in particular, is that they have helped to develop the CFD codes that are used in design. Of course we also interface with the applied side, so we are talking to architects, and our CFD experts. Our key thing for them is to provide accurate results that are visualized in a powerful way. You can communicate a very technical result, meaning you can communicate to the architects and also to the clients.

Reinier: There is quite a lot of draw in evaluating the designs that are being proposed. We analyse the designs in a very numerical way when it comes to structural or environmental performance. When it comes to daylight or energy, it is a challenge. We have quantitative analysis. However we need to communicate it in a visual way, we try to simplify it as much as possible. We try extract only the key data that matters, and we try to make it as visual, and as graphic as possible by using video and animation that communicates what we want in order to ensure that it gets through to the architect, to the client, and to the designers. We want to make sure that it is a balance of finding the right level of simplicity, and that it is accurately represented also clear.

What do you think about adaptive spaces and their potential benefits for architecture?

Jan: For us in the specialist group at Foster and Partners, it is very important that a space is experienced at its full potential. And is also tailored to what the space is actually going to be used for.

Josef Musil: I would support this [phenomena] as there is a [significant amount] of talk today on looking at multiple scenarios in architecture,
space planning, lighting, performance in general. We have a static solution, we end up having some kind of an average solution that covers a whole range, that but eventually does not works neither good on any of the cases you are trying to design for.

Miriam: We design buildings for ever-changing environments. A building that performs well, in this season, may not perform well in another season, and when you integrate adaptability in designing envelops and strategies, it brings performance to a higher level of scenarios. This is the main essence of integrating adaptability to buildings.

Bending Active Tensile Structures are often described as sculptural. Do you see a potential for these systems in architecture?

Richard: I see a lot of potential for using bending active structures. Describe them as sculptural is certainly valid to an extent, however when there is rational behind them from an engineering perspective and not just a shape finding, or shape making viewpoint, then they are valid things. I don't see any limit to their scale necessarily. We did a project for an active structure, where there was a performance space, for an outdoor theatre. The client wanted a covering for when it was too hot or when it rained, to cover hundreds or a few thousand people. Something like that could be very interesting as a bending active structure large scale thing. There is a long way to go from where we are now to get to there but that would be quite exciting, and that would not fall under the remit of sculptural. For me that would be an engineering and architectural solution.

Reinier: Bending active is really cool.
Kai Strehkle, Head of Digital Processes: So I am an architect, I studied architecture, I worked in an architectural office - for Herzog & de Meuron, where I was leading the group of digital technologies for about 10 years, and where I got the interest in jumping over the fence from design to production. This is why I started to work for Blumer Lehmann where I am translating designs from other architects into production facilities we have for complex free-form projects. We get the geometry, we get the raw material, and we have to program the production data for the machines.

What does innovation and research mean for your company?

Martin Antemann, Consultant: First of all, innovation is, by definition, that which is beneficial for the market. If it is not beneficial for the market then it is a good idea but not innovation. Be flexible, be fast, be accurate, be safe, be friendly. These are traits that give you a certain kind of innovation. Kai: In principle, I see two different methods of research. One research where there is purely academic research, which is quite far away from the market, and sometimes difficult to find a relation to the market. Then of course you have the market that is pushing for more productivity. The market and the competition between all the companies doing the same thing at the
moment, is pushing the companies, and there has to be research done within the companies to get these projects done in a much simpler way. One expectation we have is, if you want to stay cutting edge, you have to stay curious about what is being thought of, what are people investigating. Blumer Lehmann is big enough not to only focus on the short-sight market for the next project or for the next two or three projects, the interest of the company is to have this double-view, this is a productive and company-focused view.

Where do you see the value in each Innochain project that you are partnered with?

Martin: Efilena’s work is something that would be good in the mid-long term perspective. Wood has a very high and underestimated capacity here, compared to steel or other materials.

Kai: Efilena, is looking for a way of prototyping wood, which at the moment has potential for how to use the anisotropic movement of the material. How she tries to work with it, at the moment is still difficult cost-wise. How much cost will she have to invest in order to get a product out?

In the case of Tom, we used his knowledge, (particularly) of laser scanning, directly in the project of Swatch. We had raw materials that did not fit into the final workpiece, and had to do extensive research about how to position pieces on the milling machine in order to get the final pieces milled. In this context, I think Tom was extremely helpful because when we did complex balcony pieces, we could directly incorporate his knowledge and his research into the project.

Martin: What we could gain from Tom’s work is a new or different, material composition for several applications. With his recommendation, we have to decide how we want to move forward. I am happy about were we are and he is where he is. It is important for him, not only for the topic and the company, I think we have learned a lot together, and to be straight-forward. Do it. Do not study too long, but to go in the workshop, and do it.

What are the biggest barriers to effective research and collaboration?

Kai: In collaboration, what Innochain, the biggest problem is that you have a speed inside the company for the market and you have the speed that is an academic speed, and these two time values do not always match perfectly together.

Martin: It is a barrier more on the company’s side, it is not a barrier in the relationship or work with (Innochain ESRs). Also to learn what is needed to make a fast-track research within a production process. It is not the right way to think to go or to assume that you can have a machine that is 60 meters long and 5.5 meters wide, that you can have the capacity of this machine (for research) because this machine has to earn money, full stop. If you want to test something, this is the wrong machine. That is also why I told Efilena, the first machine you will get from me is a handsaw. Multiple axes... Totally flexible...

Kai: Whatever research in academia, is people want to spread it all over the world and share this kind of knowledge and results. When you have a company and you do research inside a company and you find something, you are more competitive compared to your competitors. You do not really want to share this knowledge. Another barrier for research is also, that in academia you often have teams working in fields, and very often when you talk about a PhD, you attribute the finding of the work of the PhD, to one person. In a company, you do not care about this personality much. It is much more team research or team spirit happening inside the company, these two are barriers for an effective research in Innochain - or in general between academia and industry.

What do we need to change in order to move forward?
Kai: We have to differentiate between standard architecture and non-standard architecture. That in non-standard design, the architect has to look for a collaboration between him self and the production, or the manufacturer much earlier. This communication between the architect and the manufacturer, must increase.

Martin: We need an environment where we have some kind of vertical column of knowledge. It means, on the very top, are the universities, schools, then companies and also schools for education, for craftsmen, and within this environment, all of them should come, use the same equipment. The people within this environment, have the whole knowledge of this vertical column.

Kai: We cannot neglect technology, we cannot neglect the future and cannot go back and say, “We are making hand drawings, it is better that we are going back in history.” But we have to look at all the new openings, we have to have a critical eye on them.
Jonas Runberger, Head of Dsearch: I am Jonas Runberger, I am an architect and PhD for a long time I have been exploring and investigating the role of the digital in architectural design and production, through methods and discourses, changes in culture, and practice.

I share my time between practice and academia, as an educator and as a researcher, and I think these overlap are critical to architecture.

**What is the role of research at White Arkitekter?**

White Arkitekter has a long standing tradition research development. On one hand, it means that we invest a lot in the company, we have [a research initiative called] White Research Lab. This is an internal network that supports initiatives typically bottom-up from our colleagues. Within the White Research Lab, there are four development networks that operate in direct relation to the practice. I am head of Dsearch, which is in particular the only one in the network that has a core team dedicated to the questions. We explore the role of digital and computation, particularly in practice, often through project engagements where we take on challenging issues. We develop methods in which we adapt computational approaches to our needs in practice that can also deal with how we make a quality insured, result and how we make sure that our processes work. The main objective is to introduce innovation within our practice.

**What is the expected contribution of the Innochain project to your practice?**

If one disregards the subject matter of Innochain for a second, it’s
very interesting for us to see the role of a researcher in education. What kind of roles can these individuals have in practice? It is in line with the overall Marie-Curie objective of seeing how can you actually do research in practice and that contributes, to our projects but also in terms of a wider and longer strategy of knowledge generation and dissemination of findings? Given that we also have our own industrial doctorates, we also see the value in questioning: what kind of role can a researcher have in our daily activities? We are also interested in the direct impact that a researcher and a research project can have in the projects and commissions. In most architectural practices, much of our work is related to specific projects.

What are the barriers to effective research and collaboration?

The first barrier, or potential issue, that we are aware of from the start is the differences in timelines and perspectives; to foresee the needs of a project and at what times it would be possible to influence it. Is almost that one needs to be a bit fortunate to match the questions in a research project because those need to be independent from the needs of the project. We see a big difference between the role of a researcher and one of our colleagues since we’re normally consultants, so one needs to try to match those and look for innovation. A very big issue in research, relating to fabrication where, for instance, prototyping is of great value, is tendering and the way big projects are being tendered. This is of course a set of regulations which are set in place to ensure that we have a healthy business - but they also provide barriers. It can be very difficult to do prototyping early on, not only to fund it, but if particular partner - another industrial partner, for instance - is engaged in this, it could actually prohibit future participation in actual tendering. So this is known to most practices and industries, that one needs to find ways around it. So I would say then: timelines and perspectives, the tendering is a barrier in itself, and finally I think that there are, of course, cultural differences and preconceptions of research in practice and practice in research, and I think these different cultures are important. As a researcher, you need to be able to work as a researcher which may include independence. But things can still be difficult in terms of understanding the different roles. Of course, there are so many different kinds of research approaches, and when it’s very design-oriented, maybe that becomes much closer to a practice culture, but I think there’s still a challenge here.

Where do you see the value in each Innochain project that you are partnered with?

In terms of the work of you, Tom, it’s very much aligned with aspects that we are exploring, and there’s already reception, in terms of working with timber, and we want to extend that here in Sweden. And then we align that with the fabrication aspects where, actually, we have yet to do a bigger timber project where we’ve challenged fabrication principles. That, I think, is the challenge here which we are getting into. Perhaps it’s also about challenging the Swedish producers by introducing our other related industry partners, such as Blumer-Lehmann. So there are both challenges and opportunities in both these (Innochain project) approaches and what makes them similar is, of course, that they are very much material-based. And, while architects normally define what materials are being used in projects, it’s less common that architects engage with those materials and look for alternate fabrication processes, alternate ways of using the material, in particular when when we want to argue that material performance should be a design criteria. Then we need to get into that game as well.
Silvan Oesterle, ROK, Zurich:
Stephanie’s research brings to mind buildings such as the Toyo Ito Metropolitan Opera House, where shotcrete was sprayed on metal mesh free form reinforcement, similar to tunnel construction but at an architectural scale and precision. This research advances the stage of the industry shotcrete technology through the combination of the latest drone technology with traditional mud material. From a construction point of view it allows to erect structures without the use of heavy machinery, thus it might be applicable in remote locations without road access. The use of low cost material construction such as mud that can easily be sourced locally allows this novel technology to be applied in many regions around the world with less construction industries.

Michael Daris, Drone pilot and customization RC take off:
Was an entirely new experience from space our big drones to [The experiment performed with Stephanie] built a few years ago. I am a specialised drone instructor. Have [with this protorype] we experimented with a big drone that can lift 25kg that we can spray mud with. It seems a bit silly, but I really believe in the project of Stephanie. It is actually a simple way to put together big things.

Sebastien Goessens, Researcher and Professor at UCL Loucain Engineering:
If we want to automate the drones, it is a good idea to try and assemble a lot of small pieces or parts, it could be small bricks or mud that you spray with a lot of transportation between one place and the mix.
What are the characteristics of the early design phase in your practice?

We often see that this phase is flexible and predominantly guided by loose and informal conversations, that often happen not during an official meeting. The most amount of deciding information that is also seen at the end of the project has been the outcome of discussions that could even happen in the kitchen or in any informal place. These ideas are often very easily communicated by people talking about references that those people know working on a project, and then you immediately have an idea. Then these are usually just put down as some hand sketch or even directly put into 3D because we often have to understand the complexity and nature of the problem by immediately going deep into a CAD model. Often we have seen that it is a surprise how many of these very early ideas are actually transported all the way through to the end of the project. So we would always wonder whether your tools could be installed on a tablet and put on our kitchen table, because that's really where early design is happening.
What are the different tools you are using to develop and communicate your designs within the team?

It is mostly [in the formatted] sketches, and we often later realize that if we had started parametrically straight away, it would have immediately made sense. Often too quickly be able to put down an idea and transport it, you want to find the quickest and easiest way of saving that idea in the form of a sketch, model or note. What is specific about our work is that often it begins in connection with existing building structures or existing design protocols, to which we then add a facade, additional roofing or courtyard shading. Specifically, in lightweight structures, in this case, when we start the project we have a 3D model of some existing structures that directly interfere with our proposal or that are adjacent to it. So we have a 3D model to start our work with.

How do you test and evaluate different design variations in the early design phase? What is missing in this process?

This is the reason that we enter the 3D quickly and why we do not take much time in the beginning to build a parametric model. We have to check the model in engineering software quickly to see whether the spans, heights, deflections and forces can work. With this, we have a better way of integrating our engineering tools into the CAD and parametric tools. Where we wish that things would move more naturally is in the way ideas are generated. This would be the step where we talk about ideas and put them into a sketch or into a 3D model. Creating variations on this level too.

Do you work with physical models or are you directly translating your sketches to CAD models?

In structure we rarely build physical models recently. It could also be straight away but to develop mechanics it is still quite easy with models to understand some basic principles. Especially if they are not 2D scissor mechanisms but something more complex. Approximately 10 years ago, we would build a lot of physical models. This has stopped as it has become easier to make good 3D models that can then be directly used for analysis.

Do you use any multiple criteria search tool, for example Octopus, Galapagos, or others? What is the influence of these tools in your practice? Rather, how influential are these tools in the further stages of the project development?

We used it once for a competition design of a watch tower to find out how different shapes can be generated based on the optimization of structural behavior. Other than that we use these optimization tools that are used to solve very specific problems, suches optimizing pre stress ratios in multiple cables to only have normal forces in a spoked wheel that is not circular, or reaching a certain geometry by varying the prestress of the multiple parts of a system. The multiple criteria are more the multiple variables of the same criteria which is always prestress. So it is not such a creative approach but rather looking for a very specific optimized goal. It is not such a creative approach but rather looking for very specific optimized goal.

So you integrate the multiple criteria search rather on the later stages of the design for very specific problems to optimize certain criteria right?

At the point where we know exactly what we want, we may have already performed multiple analysis on the non-optimized system. Where you can always say we will be able to optimize this part at a later stage when more variables are fixed. Its only actually in the one project that we collaborated on with you on a facade system where we looked for such criteria on early design to generate variable solutions.
What were your expectations from InnoChain Industry Partnership and which ones were fulfilled?

We have always approached this as an opportunity for someone to come in with new ideas and help us be kind of connected to latest development and be part of the developments in that making. Just for you coming in and showing us your work and discussing what you can do, also opens our perspective on what can be possible and what we might use in the future or might use in the next couple of projects. So this is something that we have experienced already as very successful. In the beginning I didn’t really expect that any of the direct outcomes of a PhD would be immediately used in our office. How I see now I think there might be some tools, ideas, and specific solutions coming up that we might start using. This is very positive development.

What does the InnoChain partnership bring to your office?

This is also what we experienced being part of the InnoChain program. What it brings to us is to have someone in the team who is only focusing on one theme, which is what I remember from my own PhD in hindsight as the biggest luxury. That one is not distracted by thousands of other things or other projects but there was really this one thing to focus on. It is great to be connected to a person who goes deeper in one subject to be a part of the first people who would get to hear about these new findings and developments and see what’s possible. So the future is looking pink!
The training at Smith Innovation title “Innovation in Practice” that took place in Copenhagen in August 2017 allowed the Innochain researchers to explore the potential of the newly developed Innochain technology to be included in the market in the coming years.

Smith Innovation specializes in water management and innovation in the built environment.

The participants had the chance to listen to key persons of the office talks including Natalie Mossin (lead of the event) Peter Hinsby and Tomassen Mikkel.

After listening to the presentations of Smith Innovation specialists the early stage researchers were invited to highlight in a short exercise what are the possible related to their research existing industries that could help launch new technologies. Emphasis on the inevitable complexity of any PhD research even more if it is related to a new technology to be integrated in the construction market requires on average a significant number of years before finding the right investors and launching new patents.

This training session was a perfect introduction and concentrated content of the Berlin Winter School to follow in October 2017.
Drivers of Innovation

Introduction

The “Winter School: Drivers of Innovation” was a week-long event that took place at the HENN GmbH office in Berlin, between the 8th and the 13th of October 2017. For the Winter School, ESRs, IPs and Universities were asked to pan out how their research will make a difference to society and building profession in a short and long-term perspective. The participants, together with the invited professionals were asked to envision and discuss scenarios and frameworks in which the InnoChain projects could be a base for the future building – or other – industry.

The objective of the Winter School was to focus the vision of the research and to project it into a possible future. For this one-week programme all the participants were asked to take a “look ahead” and create a perspective that can and should be bold and thought-provoking.
Structure

The programme was structured in 2 parts:

- Day 01-04: Introduction, Workshops, Trainings, Case Studies and Presentation Skills. (Private Event)

During the first four days of the event, the ESRs were given a series of workshops and trainings to help them create a vision of their projects and project how they could potentially transform the building industry.

- Days 05-06: Presentations, Panel discussion and Exhibition (Public Event)

During the last two days of the event, a public event that included the ESR presentations & a feedback panel discussion was hosted at HENN to conclude the work of the previous days. During the public presentations and panel discussion, the ESRs received feedback from the Industry Partners and other interested participants on their projects and visions for future development. The public event ended with the opening of the exhibition which was hosted at HENN to demonstrate the work of the Winter School.

Workshops

The workshops were guided by selected tutors of adjacent professions in order to coach ESRs in useful methods, techniques, and software applications related to the development of research into projects, that can strive and mature as businesses or services. The aim was to enrich the knowledge and skillsets of the participants by demonstrating, discussing and testing concepts and tools in a hands-on way.

Case Studies

Each workshop day ended with a case study presentation. After these presentations the workshop tutors were available for individual sessions and consultancy, which helped the ESRs develop day by day their projects into meaningful and solid proposals for disruptive technological ideas in the building sector.
Final Presentations

The final presentations formed the core of the Winter School. In them, the ESRs presented the potential and perspective of their research, as it was conceived during the previous days. The presentations provided a forum to show their visions of a future building practice and how the research conducted in the Innochain programme could influence this future. The sessions were structured in 5 blocks of 1.5 hours, divided in 3 presentations each, followed by short feedback sessions. The discussion was moderated in an “open-mic” session with the crowd and invited guests.

The public event was quite successful in generating a very interesting and engaging discussion on the projected outcome of the Innochain’s research and its potential in creating disruptive technologies for the building industry. The event was attended both by representative of the industrial partners as well as a number of interested individuals who actively engaged in the event. The discussions which were moderated by HENN’s Moritz Fleischmann, who organized the Winter School event, were quite fruitful and gave valuable feedback to the ESRs on their vision of their projects and its relevance to the building industry.

Exhibition

The public event concluded with the opening of the exhibition that displayed the Innochain projects and acted as an invitation for further discussion of what the ESRs have developed and envision for the future.

Article:
Angelos Chronis
HENN is honored to host the InnoChain Winter School in 2017. This one-week programme is a forum for exchange and innovation within and beyond the InnoChain network. Within this week we are going to discuss the future of architectural practise and how current research within the InnoChain network will shape this future.

Therefore we invite early stage researchers (ESRs), industry partners as well as academic institutions and the interested public to our premises in Berlin.

Workshops, case studies, public presentations and the InnoChain exhibition provide the fertile ground for a fruitful exchange of ideas, concerns and concepts about our future.

HENN is an international architecture office with offices in Munich, Berlin and Beijing and 65 years of expertise in the fields of culture and office buildings, teaching and research as well as development, production and masterplanning.

The office is led by Gunter Henn and nineteen partners. 350 employees – architects, designers, planners and engineers – from 30 countries are able to draw upon a wealth of knowledge collected over three generations of building experience in addition to a worldwide network of partners and experts in a variety of disciplines.

This continuity, coupled with progressive design approaches and methods and interdisciplinary research projects, forms the basis for a continual examination of current issues and for a consistent design philosophy. Forms and spaces are no mere objective, they are developed from the processes, demands and cultural contexts of each project. As a general contractor we are able to satisfy this principle at every stage of project planning and implement-ation.
The InnoChain Second Year Colloquium, which took place at COAC Barcelona between the 12th and the 14th of February 2018, has been a shared evaluation event in which all Early Stage Researcher (ESRs) presented their research development.

At the 2018 Second Year Colloquium all beneficiaries and industry partners could discuss the research development of the ESR projects in plenum. This included review and evaluation of industrial collaboration and secondment programme including the secondment periods.
Following the three day Colloquium where ESRs presented their research progress, the audience was led to the opening of the Prototypes Exhibition, where IAAC hosted the work of the ESRs for a duration of two months.

Keynote speakers, such as Enric Ruiz Geli and Aviad Almagor, gave lectures to support the further research development in field of WP3 to WP5 while invited scientists, such as Mark and Jane Burry and Christoph Gengnagel, carried out evaluation of level of work and progress within the network.
Multiple states of equilibrium for bending-active (tensile) structures

Adaptive structures

The concept of adaptive structures in the framework of Constructing the Future event by the Wroclaw University of Technology was developed to address the need for more flexible and responsive structural systems. The key idea is to create structures that can change their form in response to environmental stimuli, such as temperature, light, or mechanical forces. This approach not only enhances the functionality of buildings but also allows for a more sustainable and user-friendly design. The integration of physical actuation mechanisms, such as shape memory alloys or smart materials, enables the transformation of structures in a controlled manner, providing new possibilities for architectural expression and performance. The development of such structures requires a multidisciplinary approach, combining expertise in materials science, structural engineering, and computer simulation. The potential applications of adaptive structures are vast, ranging from responsive facades to deployable roofs and multifunctional interior spaces. The flexibility and responsiveness of these structures open up new avenues for design innovation, contributing to the emergence of smart and sustainable built environments.
ACKNOWLEDGEMENTS

The InnoChain is by nature constructed of a network of individuals, institutions and companies, without whom the content presented in the journal would cease to exist. We would like to extend a special thank you to all participants involved in the InnoChain collective collaboration.

The research in this journal has been funded by the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska - Curie grant agreement No. 642877.

Editors:
Mathilde Marengo, Lili Tayefi