Innochain
Winter School 2017

Drivers of Innovation
HENN, Berlin
DISCLAIMER
Although the author and publisher have made every effort to ensure that the information in this catalogue was correct at press time, the author and publisher do not assume and hereby disclaim any liability to any party for any loss, damage, or disruption caused by errors or omissions, whether such errors or omissions result from negligence, accident, or any other cause.

IMPRESSUM
Authors: Moritz Fleischmann, Martin Tamke, Martin Henn, Evi Slabbinck, Tom Svilans, Angelos Chronis, Zeynep Aksoz, Dimitrie Stefanescu, Paul Pointet, Efilena Baseta, James Solley, Vasily Sitnikov, Giulio Brugnaro, Helena Westerlind, Saman Saffarian, Arthur Prior, Stephanie Chaltiel

Publisher: InnoChain

Contact:
Centre for Information Technology and Architecture (CITA)
The Royal Danish Academy of Fine Arts, Schools of Architecture, Design and Conservation
Philip de Langes Allé 10
DK-1455 Copenhagen

Martin.tamke@kadk.dk
The InnoChain ETN network is a shared research training environment examining how advances in digital design tools challenge building culture enabling sustainable, informed and materially smart design solutions. The network aims to train a new generation of interdisciplinary researchers with a strong industry focus that can effect real changes in the way we think, design and build our physical environment.

The programme investigates the extended digital chain as a particular opportunity for interdisciplinary design collaboration. Challenging the traditional thinking of design as a linear process of incremental refinement, InnoChain identifies three axes of design innovation potential communication, simulation and materialisation appearing as distributed and interdisciplinary activities across the design chain.

Situating feedback between design processes as a key concern for developing holistic and integrated design methods, the network will develop new interdisciplinary design methods that integrate advanced simulation and interface with material fabrication.

With a strong inter-sector focus, InnoChain connects “research in practice” with “research in academia”. Assembling 6 internationally recognised academic research environments leading research into computational design in architecture and engineering and 14 innovation pioneering industry partners from architecture, engineering, design software development and fabrication, the programme will establish a shared training platform for 15 early stage researchers.

The network creates a structured training programme focussed on supervision of individual research projects, an inter-sector secondment programme as well as collective research events including workshop seminars, colloquia, winter school and research courses that provide a unique opportunity for young researchers to obtain new knowledge and skills positioning them between strong innovative research practice and influential industrial impact.

www.innochain.net
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 implementation.

www.henn.com
**Outline**

**Introduction**
For the Winter School ESRs, IPs and Universities are asked to pan out how their research will make a difference to society and building profession in a short and long-term perspective. Together we want to envision and discuss scenarios and frameworks in which the InnoChain projects can be a base for a future building (or other) industry.

The objective is to focus the vision of the research and to project it into a possible future. For this one-week programme we want all the participants to take a “look ahead”. This perspective can and should be bold and thought-provoking.

**Structure**
The programme is structured in 2 parts:
- **DAY 01 - DAY 04**
  Introduction, workshops, 1-1 trainings, case studies and preparation for presentation (ESRs only)
- **DAY 05 & DAY 06**
  Presentations, panel discussion and exhibition (public sessions)

**ESR Presentations & Feedback**
Each ESR has a slot of 15 min presentation followed by 10 min feedback. The idea is that the tutors gain an overview of the projects and the work in the Winter School can be defined.

**Workshops**
The workshops are guided by selected tutors of adjacent professions in order to coach ESRs and interested experts in useful methods, techniques, and software applications related to the development of research into projects, that can strive and matures as business or service. The aim is to enrich the knowledge and skillsets of all participants by demonstrating, discussing and testing concepts and tools in a hands-on way - tools for successful usage.

**Case Studies**
Each workshop day ends with a case study presentation of about 30 minutes. After these presentations the workshop tutors are available for individual sessions and consultancy.

**Sessions**
These five sessions form the core of the Winter School. In them ESRs and their Industry Partners will together present the potential and perspective of the research they have been conducting.

The sessions provide a forum to show their visions of a future building practice and how the research conducted in the InnoChain programme can influence this. Each session will offer a cross section of the design, simulation and construction processes in the building industry. In here we expect alternative and potentially conflicting visions - worth discussing. The sessions will be structured in 5 blocks of 1.5 hours, divided in 3 presentations each, followed by a short feedback session. The presentations will be formed of one ESR (and IP) from the communicating, simulating and materializing work packages. The discussion will be a moderated “open-mic” session with the crowd and invited guests.

**Final words & Exhibition opening**
The exhibition will display the merged result of ESRs and IP and is an invitation for discussion of what you have developed and envision.

**Key questions**
- How work in InnoChain can transform the building industry of the future?
- What are the important topics in the future for our profession?
What are the questions, concepts and strategies underlying architectural designs? What forms the foundation good architecture is built on and how can these original ideas be communicated? The best designs find a suitable response to the right question to start with; an adequate amount of time and effort needs to be spent to identify it. Architectural programming is about finding these questions and representing the findings in visual ways suitable to lead on to innovative design solutions. At HENN and in my previous professional life as an architect, coach and strategic designer I have dedicated my work to the socio-economic context and source code for spatial design. Beyond architectural interventions and discrete objects, I help companies, public clients or NGO’s to conceive the core of spatial concepts and facilitate the user-centered processes required to get there. Design and programming methodology will be used to identify the key message and potentials of your design and to find ways to communicate it effectively.

www.henn.com

Jörn Frenzel
HENN

Programming Workshop
MON 09.Oct.17

When you present a proposal to the developer you seek a most professional style: getting in contact with the audience, keeping their full attention, developing a clear line of thought, showing decent and informative slides. And all that combined with a natural intonation and body language to come across confident and convincing. During our workshop the participants will get the chance to give a presentation and receive professional feedback to improve their presentation and to develop their skills.

Rolf Christiansen is Speech Scientist and has a Master of linguistics and adult education. Since 1994 he supports companies and individuals in improving their communicative and rhetorical skills. He was first captured to rhetorics during his US exchange year in central New York. Studying all aspects of the subject at the University of Heidelberg has given him the profound basis to help his customers to professionalize their skills.

www.rhetorix21.de

Mie Wittenburg
Smith Innovation

Business Modelling Workshop
TUE 10.Oct.17

Extensive knowledge of funding and SMEs are particularly relevant in advising organisations and other stakeholders who need knowledge, skills and resources to develop their business or operate a development project. Sustainable urban development and climate change adaptation, and how to make agendas within these areas applicable on a political as well as practice-oriented level, are of special interest.

www.smithinnovation.dk

www.henn.com
Workshops

The workshops are guided by selected tutors of adjacent professions. Topics include Programming, Business Modelling and Presentation Skills. ESRs are educated in useful methods and techniques that help them to develop their ideas into mature business.

The aim is to enrich the knowledge and skillsets of all participants by demonstrating, discussing and testing concepts and tools in a hands-on way. Each workshop consists of 3 parts:

Part 01
09.30am- 11.30am
Tutors will explain the concepts, techniques and applications of their workshop. Goals and outline of the workshop as well as key features will be explained in detail. This topic ends with a short feedback session.

Part 02
11.30am- 01.00pm
During this phase, is to form groups and to start develop different fields of application and interest. This is highly dependent on your projects, goals and foci.

Part 03
02.00pm- 05.00pm
After lunch, the tutor will consult as individually as possible and wrap up with a short overview and a guideline on how to continue for the future.
Stefan Sechelmann was born in 1980 in Berlin, Germany. In 2007 he received a diploma in mathematics (Dipl. Math.-Techn.) of Berlin Institute of Technology. He worked together with his advisor Prof. Alexander Bobenko in the field of discrete differential geometry and received his PhD. in 2016 (Dr. rer. nat., summa cum laude).

Together with Thilo Rörig he founded VaryLab.com, a service that provides surface optimization for architects and engineers. He is also the co-founder of sopher.io, an online service that provides secure communication for teams. Stefan is a Berlin Startup Scholarship apprentice.

www.sechel.de
www.sopher.io
www.varylab.com

Philipp is concerned with the dynamics of urban transformation as one of the great challenges of our time. He has focused his work on sustainable urban innovation strategies in the areas of smart mobility, intelligent infrastructure, urban renewable energy and future city design. In his role as CEO of Tegel Projekt GmbH – a municipal company of the State of Berlin – he is responsible for the largest redevelopment project around Urban Technologies in Europe, converting a whole former inner-city airport into Europe’s central hub for future industries.

After several years, as senior consultant with McKinsey, where he specialized on high-tech and the telecommunication, information, media and electronics (TIME) industries, Philipp founded and built several companies in the digital space. He is a graduate of the University of the Arts Berlin (UdK) and holds an MSc degree and a PhD in International Management and Social Psychology from the London School of Economics and Political Science (LSE).

www.berlintxl.de

Fabian Scheurer is co-founder of Design-to-Production and leads the company’s office in Zurich. He graduated from the Technical University of Munich with a diploma in computer science and architecture and gathered professional experience as CAD-trainer, software developer and new media consultant. In 2002 he joined Ludger Hovestadt’s CAAD group at the ETH Zurich, where he co-founded Design-to-Production as a research group to explore the connections between digital design and fabrication.

At the end of 2006 Design-to-Production teamed up with architect Arnold Walz and became a commercial consulting practice, supporting architects, engineers, and fabricators in the digital production of complex design.

www.designtoproduction.com
Case Studies

During the case studies, which succeed each workshop in the afternoon, ESRs gain insight into the process of starting a business by listening to brief case study presentation. Young entrepreneurs (Dr. Stefan Sechelmann), Tech Hub Experts (Dr. Philipp Bouteiller) and established players (Fabian Scheurer) give insight into the process of creating businesses. Presentations include funding policies, pitches, failures as well as insights into successful implementation of new ideas and bringing them to live.

The case studies will be joined by HENN staff and lively discussions are desired. Each case study will take approximately 30 minutes and drinks will be served.
Public Sessions & Presentations

These five sessions form the core of the Winter School. In them ESRs and their Industry Partners will together present the potential and perspective of the research they have been conducting.

The sessions provide a forum to show their visions of a future building practice and how the research conducted in the Innochain program can influence this. Each session will offer a cross section of the design, simulation and construction processes in the building industry. In here we expect alternative and potentially conflicting visions worth discussing. The sessions will be structured in 5 blocks of 1.5 hours, divided in 3 presentations each, followed by a short feedback session. The presentations will be formed of one ESR (and IP) from the communicating, simulating and materializing workpackages. The discussion will be a moderated “open-mic” session with the crowd and invited guests.
Evy L. M. Slabbinck
ESR 01
Communication Design

Evy Laura Maurice Slabbinck is a Research Associate and tutor at the Institute of Building Structures and Structural Design at the University of Stuttgart. She obtained the degree “Master of Science in Architectural Engineering” at the Vrije Universiteit Brussel and Université Libre de Bruxelles in 2014, and also holds a Master of Science from the University of Stuttgart obtained in 2015. She gained her professional experience in various international practices, including Bollinger + Grohmann, and Teuffel Engineering Consultancy, where she worked as a membrane engineer and computational specialist in several international projects.

Evy’s interest lies in structural and parametric design, form-finding, and bending-active tensile structures. She published and presented her work at international conferences and in international journals, including IASS and IABSE. She started her research under supervision of Prof. Dr.-Ing. Jan Knippers in September 2015 as part of the Innocchain PhD research network. Her research project focuses on Integrating Isogeometric Analysis in collaboration with BIG and McNeel Europe.

Integration between design and analysis is becoming more significant, and requires an easy back and forward transfer between design and analysis geometry. Isogeometric analysis (IGA) is filling the gap between structural analysis (FEA) and design software (CAD).

Next to the fact that the isogeometric method uses the same basis for geometry and analysis, so one can avoid meshing, it has several advantages in contact problems, describing continuity, large deformation locking issues, thin shell simulation and mesh refinement. The use of IGA has been developed in several scientific fields but no advantage in architecture has yet been proven. The specific advantages of IGA have a direct overlap with the problems that occur while simulating bending-active tensile structures, i.e. contact problems that are created by the bundling and linking of bending-active elements, locking issues that are a standard problem with large deformation that requires careful fine meshing and harmonious, planar elements. Additionally there is always a trade-off between accuracy and interactivity in the design of bending active structures that may be improved through the use of the combined geometry-analysis model of IGA (fig. 04).

Within the framework of parametric and interactive design a multi-resolution simulation software, based on the IGA methodology, is proposed that enables a high level of interactivity and accuracy to be simultaneously achieved. Alongside this software development the potential of bending-active tensile hybrid structures will be analysed and the design space for these hybrid systems expanded through this new analysis possibility (fig. 01-03).
Communicating Design

Integration between design and analysis is becoming more significant, and requires an easy back and forward transfer between design and analysis geometry. Isogeometric analysis (IGA) is filling the gap between structural analysis (FEA) and design software (CAD).

Next to the fact that the isogeometric method uses the same basis for geometry and analysis, so one can avoid meshing, it has several advantages in contact problems, describing continuity, large deformation locking issues, thin shell simulation and mesh refinement. The use of IGA has been developed in several scientific fields but no advantage in architecture has yet been proven. The specific advantages of IGA have a direct overlap with the problems that occur while simulating bending-active tensile structures, i.e. contact problems that are created by the bundling and linking of bending-active elements, locking issues that are a standard problem with large deformation that requires careful fine meshing and harmonious, planar quad elements. Additionally there is always a trade-off between accuracy and interactivity in the design of bending active structures that may be improved through the use of the combined geometry-analysis model of IGA (fig. 04).

Within the framework of parametric and interactive design a multi-resolution simulation software, based on the IGA methodology, is proposed that enables a high level of interactivity and accuracy to be simultaneously achieved. Alongside this software development the potential of bending-active tensile hybrid structures will be analysed and the design space for these hybrid systems expanded through this new analysis possibility (fig. 01-03).

ESR 01
Integrating isogeometric analysis for bending-active tensile structures

Evy L. M. Slabbinck

MCNEEL and FOSTER + PARTNERS

ITKE INSTITUTE OF BUILDING STRUCTURES AND STRUCTURAL DESIGN, UNIVERSITY OF STUTTGART

fig. 01 Complex cutting pattern generation of the BAT_01 using Sofistik (www.sofistik.com) (Slabbinck E. and Suzuki S.)

fig. 02 Exploded view of the BAT_01 / a. Floating GRP bending active rod in equilibrium through a prestressed membrane / b. Prestressed doubly curved membrane / c. Structural mast hinged to base / d. Internal base / e. External base used as sitting bench (Slabbinck E. and Suzuki S.)

fig. 03 Render of the BAT_01 (Slabbinck E. and Suzuki S.)

fig. 04 Render of the BAT_01 (Slabbinck E. and Suzuki S.)
Tom Svilans is an Innochain PhD fellow at the Centre for Information Technology and Architecture in Copenhagen. His research focuses on activating the anisotropic properties of glue-laminated timber and developing a non-linear interface between practice, fabrication, and simulation in the context of design and material performance. Before joining CITA, Tom was a teaching fellow at the Bartlett Manufacturing and Design Exchange (Bmade, https://www.bartlett.ucl.ac.uk/architecture/about-us/facilities/b-made) in London where he worked with robotics and digital fabrication, and he was the technical lead at ScanLAB Projects (http://scanlabprojects.co.uk/) where he led creative projects and developed 3d scanning workflows and software.

Tom Svilans
ESR 02
Communicating Design

How can the integration of material performance and digital sensing lead to new models and modes of working between early-stage design and industrial fabrication, in the context of free-form glue-laminated timber assemblies? This research investigates the integration of free-form glue-laminated timber in contemporary architectural design and fabrication. Developments 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 this new light, potentially leading to material-driven design solutions and new structural morphologies.

The project addresses three distinct but overlapping themes in this context: the production and communication of knowledge across design, development and fabrication networks; the integration of the material performance of engineered timber into these networks through computational tools; and the application of digital sensing and acquisition tools to industrial timber fabrication workflows. The project unfolds primarily through a research-by-design method based on experiments in the form of speculative probes, prototypes, and demonstrators. The method of inquiry is therefore parallel strands of physical prototyping and information modeling, drawing on the expertise of the industrial partners and the testing of workflows through workshops, case-studies, and architectural proposals.
Communicating Design

Prototypes and workshops

The PhD uses teaching as a mechanism by which to consolidate, formalize, and disseminate the research. Teaching one-to two-week workshops for both undergraduate and masters students at KADK creates deadlines and a requirement to clean up and formalize the research into a format and scope that is suitable for the workshop topic and length. This helps the overall PhD by creating ‘checkpoints’ where development is temporarily halted for restructuring and tidying. In the long run, this creates a tidier, more accessible knowledge base and a clear and documented research path, as well as a method for disseminating the research throughout the school and other programmes.

To date, two workshops have been run: a one-week workshop with second-year IBT students which introduced students to digital modeling tools and a tactile material exploration of laminated timber beams; and a two-week workshop with CITA Masters students which looked more closely and intensively at the application of scanning, robotics, and digital fabrication to the production of speculative glulam prototypes.

As well as providing students with key skills for engaging with the technologies involved, the workshops provide a way to share some of the ideas and developments from the PhD and stimulate discussion about the research in a wider academic context.
Angelos Chronis

ESR 03
Communicating Design

Angelos is a PhD Candidate at the Institute of Advanced Architecture of Catalonia in Barcelona, as a member of the Innochain network. He teaches at IAAC and at the Bartlett School of Architecture of University College London. Previously he has been working as an Associate for the Applied Research + Development group at Foster + Partners. He holds a diploma of Architecture from the University of Patras, Greece and an MSc in Adaptive Architecture & Computation from the Bartlett School of Graduate Studies, UCL, with distinction. He is a registered Architect both in Greece and in the UK.

His main research interest lies in the integration of simulation, optimization and performance drive in the design and fabrication process with a deeper expertise in computational fluid dynamics (CFD) but he has worked across many fields including virtual & augmented reality, interactive installations, 3D scanning, spatial analysis and parametric design. He is also actively involved in scientific committees as an author, reviewer and organizer as well as participating in lectures, workshops and architecture crits internationally. He is currently the program chair of SimAUD 2016 which is going to be held in UCL, London.

Integrating Building Physics for Performance Control

Industrial Partners: Mc Neel + Foster+Partners
Academic Partner: IAAC, Spain

The project focuses on the integration of computational fluid dynamics (CFD) simulations in computational design and their potential in augmenting the environmental performance of novel material and fabrication systems. In its current stage, the research has investigated the state of the art in CFD integration through a number of key experiments – design probes – with similar objectives, that aim to assess the potential and pitfalls of the available tools.

- A large 3D printed clay wall, constructed in real scale as part of the Open Thesis Fabrication programme at the Institute for Advanced Architecture of Catalonia, with the objective to use the geometry of the wall to enhance its environmental performance.
- A research project on phase changing materials at the Centre for Information Technology and Architecture and in collaboration with Kieran Timberlake, with an objective to inform a real-time multi-scalar simulation framework.
- A workshop on earthen shell structures in collaboration with ESR15 Stephanie Chaltiel, with an objective to optimize the structure’s openings for natural ventilation.

These experiments demonstrated the limited capabilities in modelling and simulating airflow problems. Driven by this conclusion, the project aims to focus on the integration of CFD that would allow designers to get performance insight on airflow related objectives within their computational design framework.
The project focuses on the integration of computational fluid dynamics (CFD) simulations in computational design and their potential in augmenting the environmental performance of novel material and fabrication systems. In its current stage, the research has investigated the state of the art in CFD integration through a number of key experiments – design probes – with similar objectives, that aim to assess the potential and pitfalls of the available tools.

- A large 3D printed clay wall, constructed in real scale as part of the Open Thesis Fabrication programme at the Institute for Advanced Architecture of Catalonia, with the objective to use the geometry of the wall to enhance its environmental performance.
- A research project on phase changing materials at the Centre for Information Technology and Architecture and in collaboration with Kieran Timberlake, with an objective to inform a real-time multi-scalar simulation framework.
- A workshop on earthen shell structures in collaboration with ESR15 Stephanie Chaltiel, with an objective to optimize the structure’s openings for natural ventilation.

These experiments demonstrated the limited capabilities in modelling and simulating airflow problems. Driven by this conclusion, the project aims to focus on the integration of CFD that would allow designers to get performance insight on airflow related objectives within their computational design framework.
Zeynep Aksoz is a PhD Candidate at the University of Applied Arts in Vienna in Institute of Architecture (IoA) http://i-o-a.at/. She is working on EU funded Research Project INnochain. Her ongoing research topic is “Multiple Criteria Optimization in Early Design Phase”, where she focuses on the communication and integration of interdisciplinary information such as engineering performance, energy efficiency in the earlier design phases. Her main interest is developing interdisciplinary evaluation strategies and high performance simulation approximation methodologies.

Zeynep received a Master of Architecture degree from Architectural Association London’s Emergent Technologies and Design Program where her research was framing evolutionary design methodologies in Architecture. She also holds a Master of Science degree from Technical University Vienna. Additional to her international experience in award-winning offices in USA and Europe she also has been teaching in several design workshops including AA Visiting School and AA Summer DLAB.

Most theories of the design process is based on the Analysis-Synthesis-Evaluation Cycle[1]. However, this cycle is only suitable for processes with fixed requirements. However, in the early design phase the requirements are vaguely defined, the design exploration is ambiguous, mutable and fluid. It is mainly impossible to satisfy each criteria, where design should be optimized for. So, in the early design phase it is the designer who decides which criteria is important, even though this might imply that the less important requirements of the design brief are not addressed.

Early design phase needs a less rigid search strategy that supports the ambiguous nature of design, which can give the designer complete freedom of investigating the design instances with all their trade-offs, rather than limiting the designer with vaguely defined criteria to optimize for. Respectively, the research aims to develop an alternative design optimization strategy for this specific stage. Using artificial neural networks and machine learning the project is investigating a multiple criteria search method that can be an alternative to heuristics. by converting the search process into the real time navigation of the design pace.

This way not only parameters but also the objectives can become explicit controllers of the design navigation process. By adjusting the objectives, the designer can visit different design solutions that are proposed by the artificial neural network. In the next steps the project will focus on direct interaction between designer and the artificial neural network. This way the designer can influence the convergence by selecting design instances and guide the search towards own preferences. Another crucial step will be testing this system in design problems of different scales. Here both industry partners will be involved to test the tools applicability with projects of lower and higher complexity, higher and lower accuracy.
Most theories of the design process is based on the Analysis-Synthesis-Evaluation Cycle[1]. However, this cycle is only suitable for processes with fixed requirements. However, in the early design phase the requirements are vaguely defined, the design exploration is ambiguous, mutable and fluid. It is mainly impossible to satisfy each criteria, where design should be optimized for. So, in the early design phase it is the designer who decides which criteria is important, even though this might imply that the less important requirements of the design brief are not addressed.

Early design phase needs a less rigid search strategy that supports the ambiguous nature of design, which can give the designer complete freedom of investigating the design instances with all their trade-offs, rather than limiting the designer with vaguely defined criteria to optimize for. Respectively, the research aims to develop an alternative design optimization strategy for this specific stage. Using artificial neural networks and machine learning the project is investigating a multiple criteria search method that can be an alternative to heuristics by converting the search process into the real time navigation of the design pace. This way not only parameters but also the objectives can become explicit controllers of the design navigation process. By adjusting the objectives, the designer can visit different design solutions that are proposed by the artificial neural network.

In the next steps the project will focus on direct interaction between designer and the artificial neural network. This way the designer can influence the convergence by selecting design instances and guide the search towards own preferences. Another crucial step will be testing this system in design problems of different scales. Here both industry partners will be involved to test the tools applicability with projects of lower and higher complexity, higher and lower accuracy.

Design by Objectives versus Design by Parameters
Dimitrie A. Stefanescu

ESR 05
Communicating Design

Dimitrie is a maker of tools, architect, designer and programmer. He is finding and speculating new overlaps between the web, code and design challenges. His main current focus is creating digital design communication interfaces that enable the collaborative definition of value for all the stakeholders involved in the design process.

Now a Research Assistant at The UCL Bartlett School of Architecture in London, Dimitrie previously worked as an architect for the Brussels-based practice Bogdan & Van Broeck, and taught computational design in Stuttgart (ABK Stuttgart) and Berlin (TU Berlin). Since 2009, he is giving talks and tutoring workshops throughout Europe (TU Delft, TU Brno, TU Berlin, HTWK Leipzig, ZA Cluj) on information architecture, computational design and digital fabrication. He has also published several articles in print, mostly on critical theory related to the digital design paradigms (PLAT, Horizonte, Architectora).

The main goal of this research project is to analyze how complex simulation based design can be collated and communicated internally, within a design team, as well as externally, with the various stakeholders involved in the design process. 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. Existing workflows depend on centralised software solutions that are not extensible. Extensibility is usually limited to bespoke plugins that use closed protocols, thus fragmenting and limiting the interoperability between all design actors: humans, software and fabrication. All existing solutions are industry-specific and come with a high complexity overhead that makes them tedious to implement and maintain throughout the design process.

As such, there is a distinct need for a flexible set of software tools that can provide a flexible 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. The ambition of Speckle is to enable a flexible and meaningful data rich design workflow between any stakeholders (technical or non-technical) involved in the design process and allow users to structure their own communications channels and evolve their complexity gradually, from simple geometry to fully integrated BIM-like "smart" objects.
The main goal of this research project is to analyze how complex simulation-based design can be collated and communicated internally, within a design team, as well as externally, with the various stakeholders involved in the design process.

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. Existing workflows depend on centralised software solutions that are not extensible. Extensibility is usually limited to bespoke plugins that use closed protocols, thus fragmenting and limiting the interoperability (between all design actors: humans, software and fabrication). All existing solutions are industry-specific and come with a high complexity overhead that makes them tedious to implement and maintain throughout the design process.

As such, there is a distinct need for a flexible set of software tools that can provide a flexible 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.

The ambition of Speckle is to enable a flexible and meaningful data-rich design workflow between any stakeholders (technical or non-technical) involved in the design process and allow users to structure their own communications channels and evolve their complexity gradually, from simple geometry to fully integrated BIM-like “smart” objects.

“Connections rather than computations.”
Kevin Kelly @ 1997, Wired
Paul Poinet

ESR 06
Simulation for Design

Paul Poinet is holding a B.Arch. from the Ecole Nationale Supérieure d’Architecture Paris-Malaquais (ENSAPM) and a M.Sc. in Integrative Technologies and Architectural Design Research from the University of Stuttgart (ICD/ITKE).

During his Bachelor of Architecture (2010-2013), he has been working in the design development of concrete lattices at EZCT Architecture & Design Research (Paris) and was involved as a tutor assistant in different workshops focusing on parametric design tools at the Digital Knowledge Department of ENSAPM. During his Master of Science ITECH (2013-2015), he worked on the global design and the robotic fabrication of the ICD/ITKE Research Pavilion 2014-15, before completing his master thesis: Adaptive Pneumatic Shell Structures.

Collaborating with designtoproduction and Buro Happold as industrial partners, Paul is now pursuing his PhD in Multi Scalar Modelling for Building Design, focusing on timber gridshells and the interaction of different elements across multiple scales and resolutions within a global environment.

How can we improve the current state of the art in discontinuous digital workflows used in different architecture/engineering practices working on both large-scale and complex architectural projects? In order to communicate data with different trades, many architectural firms are aiming to improve their digital workflow and engage in the usage of “Building Information Modelling” (BIM). The intention is to integrate all information necessary into a holistic environment. However, when the geometrical complexity of an architectural project drastically increases, the large amount of data generated across all scales and resolutions becomes computationally expensive and difficult to handle. By reconsidering the notions of representation, scale and resolution early in the decision making design stages, Multi-Scalar Modelling (MSM) can present an opportunity to overcome discontinuities within the current modelling paradigm during conception so the access to high-resolution data related to fabrication, transport and assembly is eased at a later stage in the project. MSM can extend the classical BIM environment by linking different sub-models together, which can be triggered and modulated by the user. Multi-Scalar Simulation (MSS) can further extend MSM by integrating various simulations, which allows to optimize multiple, geometrical and/or structural parameters.

A secondment at the industry partner Design-to-Production in March-April 2017, provided an opportunity to in-depth study the digital design workflows at the office of large scale complex architectural projects. Important findings in relation to data management were made. The research helped to detect a lack of data connectivity outside of the associative modelling environment. This made it difficult to answer questions for specific information from third party, that might be spread vertically and horizontally across different models.
Multi-Scalar Modelling for Free-form Timber Structures & Building Design

Paul Poinet

Industrial partner: BURO HAPPOLD

Academic partner: CITA

Centre for Information Technology and Architecture (CITA), The Royal Danish Academy of Fine Arts Schools of Architecture, Design and Conservation
Efilena Baseta is an architect engineer, studied in the National Technical University of Athens (NTUA), with a Master degree in Advanced Architecture from the Institute for Advanced Architecture of Catalonia (IAAC). Her interest lies in exploring material behaviors, physically and digitally, in order to create real time responsive structures. Since 2014 Efilena is a partner of Noumena, an experimental architectural practice based in Barcelona. She has led several workshops internationally and also has been part of the design and coordination of exhibitions related with technology, such as the “Pavilion of Innovation 2015” and “In3dustry”. During 2015-2016 she collaborated with IAAC as the coordinator of the Visiting Programs and tutor of the Global Summer School 2016. She is currently an innochain PhD candidate in the Institute of Architecture at the University of Applied Arts Vienna on the topic of Simulating Anisotropic Material.

What if architecture was adaptive to its surroundings, like living beings, and not a foreign body that cannot react to it? In this framework, which would be the design principles of this kind of architecture and from which materials would it be made?

In this framework, this research investigates the relations between the microstructure of shape changing materials and their mesoscalar deformations, in an attempt to apply similar logic to scale up the mesoscalar deformations to macroscalar kinetic structures.

The goal is to create an innovative construction system which considers structural elements as soft actuators that adapt to stimuli from the surroundings, by embedding material simulation in the design process.

Respectively, by creating hierarchical structural material systems with fibrous composites, self-actuation can be achieved in similar ways as in plants, where the hierarchy and the anisotropic characteristics of the parts (2 layers), is proved to be the driving force of a programmed deformation (bending or twisting).

In Mesoscale, physical experiments with various configurations of 2 layers composites, including wood veneer strips (10 x 2cm) have been conducted in order to document and extract data of their deformation upon changes in relative humidity. Speculating the scaling up the system in Macroscale, the rigid 2 layer principle that has been applied in the aforementioned experiments, is suggested to be augmented by embedding an adaptive stiffness zone between the parts, allowing controlled deformation of the stiff, yet flexible parts.
What if architecture was adaptive to its surroundings, like living beings, and not a foreign body that cannot react to it? In this framework, which would be the design principles of this kind of architecture and from which materials would it be made?

In this framework, this research investigates the relations between the microstructure of shape changing materials and their mesoscalar deformations, in an attempt to apply similar logic to scale up the mesoscalar deformations to macroscalar kinetic structures. The goal is to create an innovative construction system which considers structural elements as soft actuators that adapt to stimuli from the surroundings, by embedding material simulation in the design process.

Respectively, by creating hierarchical structural material systems with fibrous composites, self-actuation can be achieved in similar ways as in plants, where the hierarchy and the anisotropic characteristics of the parts (2 layers), is proved to be the driving force of a programmed deformation (bending or twisting).

In *Mesoscale*, physical experiments with various configurations of 2 layers composites, including wood veneer strips (10 x 2cm) have been conducted in order to document and extract data of their deformation upon changes in relative humidity. Speculating the scaling up the system in *Macroscale*, the rigid 2 layer principle that has been applied in the aforementioned experiments, is suggested to be augmented by embedding an adaptive stiffness zone between the parts, allowing controlled deformation of the stiff, yet flexible parts.

**ESR 07 Simulating Anisotropic Material**

*Efilena Baseta*  
**INDUSTRIAL PARTNER**  
CLOUD9 + BLUMER LEHMANN  
**ACADEMIC PARTNER**  
IOA INSTITUTE OF ARCHITECTURE (IOA), THE UNIVERSITY OF APPLIED ARTS VIENNA

**MESO**

- Stress
- Humidity
- Active
- Passive

**MACRO**

- Actuator: Force
- Adaptive stiffness (kN)
- Active
- Passive

**SPALICE C50**

- Creep (1%, 5%)
James Solly is a Research Associate and tutor at the Institute of Building Structures and Structural Design (ITKE) (http://www.itke.uni-stuttgart.de/) at the University of Stuttgart.

He completed a Master’s in Engineering Science at the University of Oxford in 2008 before working with Ramboll UK and BuroHappold Engineering until 2015 on the design and realisation of computationally or geometrically complex sculpture and building projects. He qualified as a Chartered Engineer (MICE) in 2014.

James is interested in the application of computation in engineering practise both as an extension of current design strategies and as a tool for streamlining collaboration between designer, engineer and fabricator. His work to date has been defined by projects that cannot be entirely pre-designed and require physical testing or intelligent fabrication systems to calibrate engineering simulation. This has the added benefit of letting him step away from the computer and get his hands dirty in the lab or on site.

James started his research under the supervision of Prof. Dr.-Ing. Jan Knippers in September 2015 as part of the Innochain research network (http://innochain.net). His research project focuses on the Virtual Prototyping of FRP in collaboration with Foster+Partners and S-Form.

Coreless Filament Winding is a novel process for the fabrication of Fibre Reinforced Polymer (FRP) building 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 filaments around a minimal skeletal framework. Following material curing, the mesh-like fibrous components can be demounted from this framework, allowing the fabrication of subsequent components to commence. During winding, the sequentially-placed fibres wind around each other, generating the overall component geometry and enabling specific lines of material to be placed. This controllable additive process and the high strength-to-weight ratio of FRP materials enables lattice composite components to be created with minimum material usage. This, ease of assembly (due to the lightweight parts) and the possibility of local-to-site fabrication make the system attractive for use in the construction industry.

To understand fibre interaction, the current design process requires multiple stages of prototyping from hand-wound models to full-scale test elements before the final component details can be resolved, limiting practical usage of coreless filament winding in typical building design workflows. This research seeks to describe the physical and geometric rules behind the fibre interactions and from this develop lightweight design and simulation strategies such that Virtual Prototyping can better support early-stage design iteration for coreless-wound composite parts. The work has been developed through the involvement of this researcher in two coreless filament winding demonstrator projects, the Elytra Filament Pavilion (V&A Museum, London then Vitra Campus, Weil am Rhein) and the ICD/ITKE Research Pavilion 2016/2017.
Coreless Filament Winding is a novel process for the fabrication of Fibre Reinforced Polymer (FRP) building 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 filaments around a minimal skeletal framework. Following material curing, the mesh-like fibrous components can be demounted from this framework, allowing the fabrication of subsequent components to commence.

During winding, the sequentially-placed fibres wind around each other, generating the overall component geometry and enabling specific lines of material to be placed. This controllable additive process and the high strength-to-weight ratio of FRP materials enables lattice composite components to be created with minimum material usage. This, ease of assembly (due to the lightweight parts) and the possibility of local-to-site fabrication make the system attractive for use in the construction industry.

To understand fibre interaction, the current design process requires multiple stages of prototyping from hand-wound models to full-scale test elements before the final component details can be resolved, limiting practical usage of coreless filament winding in typical building design workflows. This research seeks to describe the physical and geometric rules behind the fibre interactions and from this develop lightweight design and simulation strategies such that Virtual Prototyping can better support early-stage design iteration for coreless-wound composite parts.

The work has been developed through the involvement of this researcher in two coreless filament winding demonstrator projects, the Elytra Filament Pavilion (V&A Museum, London then Vitra Campus, Weil am Rhein) and the ICD/ITKE Research Pavilion 2016/2017. For further details see the ESR08 page of the Innochain website.
Vasily Sitnikov is PhD candidate at KTH Royal Institute of Technology, Stockholm. His 4 years spanning research is dedicated to behavior of fresh concrete and means of its digital simulation. Combining physical probes and numeric experiments in the methodology of the investigation, the research aspires to establish a novel concrete casting technology, which intrinsic principals would allow a high presence of digital simulation in the stage of design modelling.

Having a background in computational design for architecture and expertise in concrete technologies, Vasily is experienced in inter-disciplinary collaboration. Starting his career as an assistant of chief technologist in a high performance concrete laboratory in Moscow, he has then attended the postgraduate programme in Staedelschule Architecture Class http://sac.staedelschule.de/en, successively presenting his thesis project on ACADIA 2014 Digital Conference in Los Angeles. Later he has worked with Berlin-based artist and architect Tomás Saraceno.

In order to minimize the amount of cement involved in concrete constructions, the concrete industry today chooses to reduce the share of cement in the total mass of concrete. This approach leads to lower mechanical properties of concrete, resulting in thicker floor slabs and massive beams.

An alternative strategy is to increase the share of cement in the total mass, and to use far less of the much stronger concrete, specifically Ultra-High Performance Concrete (UHPC). While saving up to 70% of the total concrete mass, UHPC is capable of performing without any reinforcement. Here computation of the overall structural geometry becomes important and can be resolved with existing FEA algorithms. The trade-off is the increased formal complexity - the optimized free-form geometry has no efficient method of industrial fabrication. To be integrated in the real-world context, this strategy requires a new method of fabrication of highly complex individual formwork.

Initial experiments have shown that non-reinforced UHPC can successfully harden in sub-freezing temperatures. This provided a ground to think of a method of producing a formwork completely out of ice. Although counter intuitive, it is still obvious that ice has certain properties that are beneficial in relation to casting complex forms in concrete: the use of ice eliminates all mold-related material waste, the demolding does not require manual labor, and finally the mold itself can be produced through incremental melting deformations. In combination with the fact that ice requires relatively small changes in temperature in its own production, the method is potentially sustainable, reading industrial refrigerator as a new type of kiln.
In order to minimize the amount of cement involved in concrete constructions, the concrete industry today chooses to reduce the share of cement in the total mass of concrete. This approach leads to lower mechanical properties of concrete, resulting in thicker floor slabs and massive beams.

An alternative strategy is to increase the share of cement in the total mass, and to use far less of the much stronger concrete, specifically Ultra-High Performance Concrete (UHPC). While saving up to 70% of the total concrete mass, UHPC is capable of performing without any reinforcement. Here computation of the overall structural geometry becomes important and can be resolved with existing FEA algorithms. The trade-off is the increased formal complexity - the optimized free-form geometry has no efficient method of industrial fabrication. To be integrated in the real-world context, this strategy requires a new method of fabrication of highly complex individual formwork.

Initial experiments have shown that non-reinforced UHPC can successfully harden in sub-freezing temperatures. This provided a ground to think of a method of producing a formwork completely out of ice. Although counterintuitive, it is still obvious that ice has certain properties that are beneficial in relation to casting complex forms in concrete: the use of ice eliminates all mold-related material waste, the demolding does not require manual labor, and finally the mold itself can be produced through incremental melting deformations. In combination with the fact that ice requires relatively small changes in temperature in its own production, the method is potentially sustainable, reading industrial refrigerator as a new type of kiln.

**ESR 09**

**Simulating Concrete Formwork**

Vasily Sitnikov

**Industrial Partner**
BURO HAPPOLD

**Academic Partner**
KTH SCHOOL OF ARCHITECTURE, ROYAL INSTITUTE OF TECHNOLOGY, STOCKHOLM

**Fig. 01** Experimental Sequence 2.1 - The resultant concrete panel produced with ice formwork with dimensions of 0.4x0.6 meters.

**Fig. 02** Experimental Sequence 2.1 - The processing of ice to achieve high local complexity we use a technique that exploits natural deformation of ice surface subject to melting.

**Fig. 03** Experimental Sequence 2.1 - In order to prove the concept of sub-zero concrete we have explored the nature of Ultra High Performance Concrete (UHPC).
Giulio Brugnaro

ESR 10
Simulation for Design

Giulio Brugnaro is a trained architect with a strong interest in computational tools and robotic fabrication for architectural production. He is currently Early-stage Researcher (ESR) at The Bartlett School of Architecture in London as part of the InnoChain Research Network. His research focuses on exploring adaptive robotic fabrication processes and sensing methods that allow designers to engage with the qualitative properties of heterogeneous materials. Giulio’s interest in the use of technology within creative practices led him to work through different disciplinary fields and merge them together to reach innovative and unexpected results.

Previously he received a B.Arch. in “Architectural Sciences” at IUAV University of Venice and a M.Sc. in “Integrative Technologies and Architectural Design Research” at the University of Stuttgart.

Simulating Robotic Feedback

Industrial Partners: ROK + BIG
Academic Partner: BSA/UCL, United Kingdom

The project focuses on subtractive manufacturing with timber and non-standard numerically controlled fabrication tools to develop a series of case studies investigating in depth the potential and limits of such approach. At the core of the research finds place the development of an adaptive robotic fabrication framework including software interface tools, custom end-effectors, robotic control strategies, sensing procedures (e.g. 3D scanning, force feedback) and material testing, articulated around two main areas:

- A simulation environment that locally describes the workpiece, for example a log or wooden block, storing and updating multiple layers of fabrication “affordances”.
- A trained robotic fabrication agent able to communicate through feedback loops and operate, increasingly well, within this environment. The training of the system is based on recordings of skilled human experts performing carving procedures with chisels and gouges and recordings of robotic explorations operating directly with the material. The recorded information from both activities is compiled into datasets and used within a machine learning procedure (Artificial Neural Network) to train an adaptive robotic system for subtractive fabrication processes with a similar range of materials and tools.

The research is being conducted in an ongoing dialogue with the two design firms ROK (Zurich) and BIG (Copenhagen) as industry partners. The upcoming secondments will offer the opportunity to introduce the adaptive fabrication framework and evaluate it as a design tool in the context of a professional environment through commissioned projects at the scale of a small pavilion, interiors or furniture assembly.
Integrating sensing with robotic fabrication procedures, the research investigates potential methods for analysing qualitative material feedback and integrate them into the design environment as the fabrication unfolds, challenging the unidirectional progression of current design workflows.

Introducing robotic manufacturing within the studio environment allows designers to actively engage with the fabrication process as a moment of design exploration, where the combination of heterogeneous material and tools affordances are used as active design drivers, uniquely shaping its outcome, mediating with the initially defined digital shape.

The project focuses on subtractive manufacturing with timber and non-standard numerically controlled fabrication tools to develop a series of case studies investigating in depth the potential and limits of such approach. At the core of the research finds place the development of an adaptive robotic fabrication framework including software interface tools, custom end-effectors, robotic control strategies, sensing procedures (e.g. 3D scanning, force feedback) and material testing, articulated around two main areas:

• A simulation environment that locally describes the workpiece, for example a log or wooden block, storing and updating multiple layers of fabrication “affordances”.

• A trained robotic fabrication agent able to communicate through feedback loops and operate, increasingly well, within this environment. The training of the system is based on recordings of skilled human experts performing carving procedures with chisels and gouges and recordings of robotic explorations operating directly with the material. The recorded information from both activities is compiled into datasets and used within a machine learning procedure (Artificial Neural Network) to train an adaptive robotic system for subtractive fabrication processes with a similar range of materials and tools.

The research is being conducted in an ongoing dialogue with the two design firms ROK (Zurich) and BIG (Copenhagen) as industry partners. The upcoming secondments will offer the opportunity to introduce the adaptive fabrication framework and evaluate it as a design tool in the context of a professional environment through commissioned projects at the scale of a small pavilion, interiors or furniture assembly.

Digital Craftsmanship: Robotic Training for Subtractive Manufacturing Processes
Helena Westerlind is a PhD Candidate at the KTH School of Architecture within the InnoChain training network. Her research investigates the morphology of concrete with the aid of computer controlled depositing technology. By eliminating the need of formwork in concrete construction the project seeks to examine ways of integrating material behaviour in newfound relationships between materiality and form. The project originates from a strong interest in the role of technology in exploring inherent potential in materialities and the notion of craftsmanship using digital tools.

Helena studied architecture at the Architectural Association School Architecture before joining the art studio Factum Arte in 2012. Based in Madrid the studio consists of a multi-disciplinary team dedicated to the merging of digital technologies and craft in the realisation and preservation of cultural heritage.

Form(less) concrete deposition

Industrial Partner: White
Academic Partner: KTH, Sweden

The introduction of additive manufacturing technology 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 standardisation and simplification of architectural elements. This research project, explores controlled deposition of concrete at the intersection of material science and architecture, in search of newfound correspondences between material composition, concrete performance and the choreography of flow.

The operation of placing concrete by deposition signifies a fundamental departure from conventional casting techniques in that the formalisation of concrete flow, no longer is determined by the restraint and control provided by a static formwork, but by the self-supporting capacity of the material itself, coupled with the movement involved in the deposition process. This change represents, not only, a significant technological shift, but also, a potential conceptual leap towards an understanding of concrete as active matter, and a new tectonic in concrete practice.

The overall aim of the project is concerned with advancing the use of concrete within the built environment, and optimising the use of material resources, by pursuing the possibility of varying the composition of the concrete used within a structure depending on local performance requirements. For this purpose, the project is developing the concept of ‘material resolution’ and investigating how the process of deposition can be controlled to operate a gradient of material performances (from low to high performance concrete mixes) according to design intent and material efficiency in the making of prefabricated architectural elements.
Choreographing flow

The introduction of additive manufacturing technology 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 standardisation and simplification of architectural elements.

This research project, explores controlled deposition of concrete at the intersection of material science and architecture, in search of newfound correspondences between material composition, concrete performance and the choreography of flow.

The operation of placing concrete by deposition signifies a fundamental departure from conventional casting techniques in that the formalisation of concrete flow, no longer is determined by the restraint and control provided by a static formwork, but by the self-supporting capacity of the material itself, coupled with the movement involved in the deposition process. This change represents, not only, a significant technological shift, but also, a potential conceptual leap towards an understanding of concrete as active matter, and a new tectonic in concrete practice.

The overall aim of the project is concerned with advancing the use of concrete within the built environment, and optimising the use of material resources, by pursuing the possibility of varying the composition of the concrete used within a structure depending on local performance requirements. For this purpose, the project is developing the concept of ‘material resolution’ and investigating how the process of deposition can be controlled to operate a gradient of material performances (from low to high performance concrete mixes) according to design intent and material efficiency in the making of prefabricated architectural elements.
Saman Saffarian
ESR 12
Materialising Design

Saman Saffarian is a Research Associate at the Institute for Building Structures and Structural Design (ITKE) at the University of Stuttgart. He holds a Master's degree in Architecture from the University of Applied Arts in Vienna (Universität für Angewandte Kunst Wien) and a Master’s degree in Architecture and Urban Planning from Brno University of Technology in the Czech Republic.

Previously he worked for Zaha Hadid Architects in London as a Lead Designer within ZHA Design Cluster and was involved in concept-stage design of many projects and competitions of various scales. In collaboration with the ZHA-CoDe group he contributed to the design and fabrication of a number of experimental and research-based installations and pavilions.

He has been involved in teaching as an AA visiting school tutor and guest lecturer and Studio Lead in Liberec Technical University and is currently a member of the teaching staff of the ITECH program at the University of Stuttgart.

Sam started his research under the supervision of Prof. Dr.-Ing. Jan Knippers in September 2015 as part of the Innocain research network (http://innocain.net). His research project focuses on Adaptive Building Envelopes within the Material Gradient FRP topic in collaboration with Structure and S-Form.

Material Gradient FRP

Industrial Partners: Str.ucture + S-Form
Academic Partner: ITKE, Germany

Compliant Mechanisms represent a valid alternative to rigid mechanisms for movement generation. Relying on elastic material deformation to achieve transformation, these systems dramatically reduce mechanical complexity, simplify fabrication and economise operation. The potentials of these Elastic Kinetic systems and can be harnessed to design and manufacture novel Climate Adaptive Architectural Envelopes that not only alleviate well-known problems of existing Kinetic Facades, but also provide an arguably more elegant solution for complex architectural forms.

Focusing on Fiber Reinforced Polymers (FRP) this project investigates methods of precise fiber deployment and layup patterns, to create varying material stiffness in a systematic way to achieve movement efficiency and optimized cyclic performance. In order to provide a comprehensive and detailed study of the elastic kinetic performance of FRP, a shape specific element (FlectoFold) has been strategically selected as a template for analysis. Performance enhancing geometric parameters, material specifications, actuation systems and control mechanisms are being identified and studied in parallel. The results of these investigations will be showcased in the form of a fullscale Kinetic Demonstrator highlighting the potentials and restrictions of Elastic Kinetic systems in terms of architectural design and technical performance.
Compliant Mechanisms represent a valid alternative to rigid mechanisms for movement generation. Relying on elastic material deformation to achieve transformation, these systems dramatically reduce mechanical complexity, simplify fabrication and economise operation. The potentials of these Elastic Kinetic systems can be harnessed to design and manufacture novel Climate Adaptive Architectural Envelopes that not only alleviate well-known problems of existing Kinetic Facades, but also provide an arguably more elegant solution for complex architectural forms.

Focusing on Fiber Reinforced Polymers (FRP) this project investigates methods of precise fiber deployment and lay-up patterns, to create varying material stiffness in a systematic way to achieve movement efficiency and optimized cyclic performance. In order to provide a comprehensive and detailed study of the elastic kinetic performance of FRP, a shape specific element (FlectoFold) has been strategically selected as a template for analysis. Performance enhancing geometric parameters, material specifications, actuation systems and control mechanisms are being identified and studied in parallel. The results of these investigations will be showcased in the form of a full-scale Kinetic Demonstrator highlighting the potentials and restrictions of Elastic Kinetic systems in terms of architectural design and technical performance.
Arthur Prior is a Marie Curie Researcher at the Bartlett School of Architecture, London. He is currently pursuing practice-based research into hybrid manufacturing processes, employing the use of both additive and subtractive fabrication strategies.

Before joining the Bartlett School of Architecture in 2015, Arthur worked with the Madrid-based company, Factum Arte - an organisation renowned for its ambitious public projects within the cultural heritage sector as well as its collaborations with some of the world's leading contemporary artists.

Arthur’s combined interest in art and technology has shaped a particular outlook on the role of craft within computer-automated processes. His previous projects, which have focused on 3D scanning and methods of re-materialising digital data, are marked by an interest in the interaction between computational tools and physical matter.

Hybrid manufacturing is an emerging research topic exploring the fusion of complementary manufacturing technologies. Hybrid techniques arise from a need to overcome the constraints that are inherent in two dissimilar manufacturing processes; the processes in question here are additive and subtractive manufacturing. This project addresses the limitations of additive manufacturing as a scalable fabrication process, pointing to new strategies for its integration within construction culture.

A prototype hybrid manufacturing system has been developed that builds components made of a composite wax material. A key feature of this material is its high percentage of fillers that modify its properties of consistency, cohesion, adhesion and dimensional stability. As a shear-thinning material, it ideally suited to extrusion based additive manufacturing processes. At the same time, it has excellent machinability properties, producing an excellent surface finish with low power consumption and prolonged tool-life. It is reusable and can also be sculpted by hand.

Working in collaboration with Foster + Partners, Buro Happold Engineering, Laing O’Rourke and Chavant, the research investigates this hybrid manufacturing technology as a customisation-enabling tool for architectural construction. This enquiry takes place both through practical testing of materials and tooling and through a series of application-based case-studies carried out in conjunction with industrial partners.
Hybrid manufacturing is an emerging research topic exploring the fusion of complementary manufacturing technologies. Hybrid techniques arise from a need to overcome the constraints that are inherent in two dissimilar manufacturing processes; the processes in question here are additive and subtractive manufacturing. This project addresses the limitations of additive manufacturing as a scalable fabrication process, pointing to new strategies for its integration within construction culture.

A prototype hybrid manufacturing system has been developed that builds components made of a composite wax material. A key feature of this material is its high percentage of fillers that modify its properties of consistency, cohesion, adhesion and dimensional stability. As a shear-thinning material, it ideally suited to extrusion based additive manufacturing processes. At the same time, it has excellent machinability properties, producing an excellent surface finish with low power consumption and prolonged tool-life. It is reusable and can also be sculpted by hand.

Working in collaboration with Foster+Partners, Buro Happold Engineering, Laing O’Rourke and Chavant, the research investigates this hybrid manufacturing technology as a customisation-enabling tool for architectural construction. This enquiry takes place both through practical testing of materials and tooling and through a series of application-based case-studies carried out in conjunction with industrial partners.
Stephanie Chaltiel is a PhD candidate at IAAC part of the InnoChain network on small scale robotic manufacturing for large scale buildings. Stephanie has worked for Bernard Tschumi in New York (IFCA, Dominican Republic), OMA (Monaco Extention on the water), and Zaha Hadid in London (Les Pierres Vives Montpellier). Stephanie also has valuable experience in countries such as Mexico, and French Guyana, applying sustainable materials and digital techniques for housing solutions with the support of CRATerre Unesco. In 2012, Stephanie was teaching at SUTD (Singapore University of Technologies and Design in Singapore). In addition to teaching in various universities in the UK (Architectural Association, Westminster, Ravensbourne, Brighton) and at iaac Barcelona. She is the director of the AA Visiting School in Lyon where she investigates and explores the use of digital technologies in the construction of earthen structures.

Small Scale Robotic Manufacturing for the Large scale buildings

Industrial Partners: Mc Neel + ROK
Academic Partner: BSA/UCL, United Kingdom

This research is based on exploring the potential of including robotic actions in the edification process of monolithic earthen shells. Wattle and daub has been elected as the traditional process to be translated and interpreted into digital fabrication, allowing freeform geometries and precise phasing of depositing the raw clay mixes on soft formworks, in addition to the many finish aesthetics it provokes. By easing some of the laborious tasks this research argues that specific manual craft can be included in innovative sustainable shells constructions.

The digital fabrication of monolithic earthen shells takes advantage on computation methods controlling the robotic clay mix deposition and the different resulting forms and textures it allows while respecting a precise phasing and tools’ calibration. Circular data flow between structure deformation, iterative 3d scanning and constant recalibration of the robotic actions will be explored. Physical teaching seminars at iaac and intensive workshops at international conferences (Smart Geometry 2016) have allowed the exploration of robotic spraying calibration and tests on the different resulting finish of the earthen shells. Papers co written with Maite Bravo (iaac) have allowed the project to position itself at the core of the research questions underlying innochain. (Collaborative work, fabrication precise phasing, manual craft, and robotic manufacturing). The topic of the PhD has been narrowed down to renewing wattle and daub technique paired with drones 3d scanning and drones spraying.
Small Scale Robotic Manufacturing for the Large scale buildings

Stephanie Chaltiel

This research is based on exploring the potential of including robotic actions in the edification process of monolithic earthen shells. Wattle and daub has been elected as the traditional process to be translated and interpreted into digital fabrication, allowing freeform geometries and precise phasing of depositing the raw clay mixes on soft formworks, in addition to the many finish aesthetics it provokes. By easing some of the laborious tasks this research argues that specific manual craft can be included in innovative sustainable shells constructions. The digital fabrication of monolithic earthen shells takes advantage on computation methods controlling the robotic clay mix deposit and the different resulting forms and textures it allows while respecting a precise phasing and tools’ calibration. Circular data flow between structure deformation, iterative 3d scanning and constant recalibration of the robotic actions will be explored. Physical teaching seminars at Iaac and intensive workshops at international conferences (Smart Geometry 2016) have allowed the exploration of robotic spraying calibration and tests on the different resulting finish of the earthen shells. Papers co written with Maite Bravo (Iaac) have allowed the project to position itself at the core of the research questions underlying innochain. (Collaborative work, fabrication precise phasing, manual craft, and robotic manufacturing). The topic of the PhD has been narrowed down to renewing wattle and daub technique paired with drones 3d scanning and drones spraying.

fig.01-06
Smart Geometry 2016. Gothenburg (Cluster Champions Chaltiel and Dubor) Mud, Fabrics and Robots for large structures. Kuka Agilus robotic arm connected to concrete hand sprayer and heavy paint sprayer to coat according a precise phasing a temporary bending rods and fabrics formwork.

fig.07-14
Phriends for Shells seminar at Iaac. May 2016. Kuka Robotic arm spraying matter according to precise phasing. Work on perforations of the shells.

fig.15-17
The exhibition will display the merged result of ESRs and IPs. Every work is shown on one poster (594mm x 841mm) and as prototype. In addition, screens will be available to display workshop outcomes of the previous days. The exhibition is an invitation for discussion of what you have developed and envision.
Martin Tamke is Associate Professor at the Centre for Information Technology and Architecture (CITA) in Copenhagen. He is pursuing a design led research in the interface and implications of computational design and its materialization. He joined the newly founded research centre CITA in 2006 and shaped its design based research practice. Projects on new design and fabrication for wood and fibre based materials led to a series of research projects and digitally fabricated demonstrators that explore an architectural practice engaged with bespoke materials and behaviour. Martin initiated and conducted research projects in the emerging field of digital production in building industry and architectural computation. The research connects academic and industrial partners from architecture and engineering, computer and material science and the crafts. Currently he is involved in the EU framework 7 project DURAARK, the Danish funded 4 year Complex Modelling research project and the adapt-r and InnoChain PhD research networks.

www.goo.gl/KErkSm

Mette Ramsgaard Thomsen research centres on the intersection between architecture and computer science. During the last 15 years her focus has been on the profound changes that digital technologies instigate in the way architecture is thought, designed and built. In 2004 she completed an interdisciplinary PhD in architecture and computer science, and in 2005 she founded the Centre for IT and Architecture research group (CITA) at the Royal Academy of Fine Arts, School of Architecture, Design and Conservation. In 2010 Mette became full Professor in Architecture and Digital Technologies. In CITA she piloted a special research focus on the new digital-material relations that digital technologies bring forth. Investigating advanced computer modelling, digital fabrication and material specification CITA has been central in the forming of an international research field examining the changes to material practice in architecture. This has been led by a series of research investigations developing concepts and technologies as well as strategic projects such as the international Digital Crafting Network and the InnoChain research project.

www.goo.gl/zJBEwL
Martin Henn, Dipl.-Arch., M.S. AAD
HENN Design Director / Partner
InnoChain Industry Partner

Martin Henn studied architecture at the University of Stuttgart and at the ETH Zürich. He received his Master’s Degree in Architecture from the ETH, Zürich in 2006, and his Post-Professional Master of Advanced Architectural Design from Columbia University, New York in 2008. Prior to HENN, he was working for Zaha Hadid Architects (London) and Asymptote Architecture (New York). He has been a regular studio and seminar instructor at the ETH in Zürich, at Columbia University as well as at the TU Dresden.

www.henn.com

Moritz Fleischmann, Prof., Dipl.-Ing., M. Arch.
HENN Research Consultant
InnoChain Industry Partner

Moritz Fleischmann is a professor for computational design at the Hochschule Düsseldorf (HSD). His research investigates the impact of computer technology on early design stages and transdisciplinary collaborations in architecture. He has published widely and held lectures at numerous international conferences. At HENN, he organizes the Design Research Exchange (DRX) and is responsible for the InnoChain project.

www.henn.com
HENN is an international architectural practice based in Germany with more than 30 years of experience in designing culture, education, production, and research and development buildings. The office is managed by Prof. Dr. Gunter Henn and nine partners. Approximately 330 architects, planners and engineers work in the HENN offices in Munich, Berlin, Beijing and Shanghai.

Alexanderstr. 7, 8th Floor
10178 Berlin
Germany

T. +49 (0)30 28 30 99 -0

www.henn.com

Academic & Industrial Partners

Sponsors

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under the Marie-Sklodowska-Curie grant agreement No 642877.