Towards a Multi-Scalar Modelling Paradigm for Architecture, Engineering and Construction

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Abstract
The present research work has been carried within the InnoChain ETN network, which has received funding from the European Union's Horizon 2020 research and innovation program under the Marie-Sklodowska-Curie grant agreement No 642877. InnoChain aims to expand, synthesize and consolidate knowledge into computation-informed building design practice across academia and practice. The thesis inscribes itself as well at the intersection of academia in practice, through its academic supervision at the Centre of Information Technology and Architecture (CITA), and the involvement of two industrial supervisors: BuroHappold (London, UK) and Design-to-Production (Zurich, Switzerland), specialized respectively in engineering consultancy and in the geometrical rationalization of complex timber structures.

The present thesis takes as a starting point the Multi-Scalar Modelling framework formulated and established by the Centre of Information Technology and Architecture (CITA) through the conception, production and realization of precedent design probes, prototypes and demonstrators (e.g. The Rise, Dermoid, Lace Wall and Stressed Skins). Those demonstrators introduced Multi-Scalar Modelling strategies enabling a direct communication between multiple scales, from material specifications at high resolution to the global design environment.
The thesis attempts to extend this theoretical framework by adapting it to the building scale through further inclusion of industry concerns and problematics, provided here by both BuroHappold and Design-to-Production: trying to keep a consistent, continuous design workflow throughout the whole design process, from early design to late stages. The current existing workflows are segregated, and this can be explained by two main reasons: the first is that trying to maintain a complete continuous digital chain is a *wicked problem* and is most probably promised to collapse. The second is that the different trades involved in a particular project are using a wide range of different software platforms, which hardly communicate between themselves, beyond traditional export-import practices and email attachment workflows.
Therefore, the principle objective of this thesis is to redefine the Multi-Scalar Modelling framework (focusing on digital infrastructure across different scales and phases of a demonstrator project) specifically for Building Design and AEC (Architecture, Engineering and Construction). This framework will demonstrate, through a series of conducted modelling experiments and prototypical interfaces, the possibility of implementing more consistent digital design workflows and software interfaces, whose ultimate aim would be to solve some of the current issues faced by the AEC industry, especially during the conception and realization of a large-scale and geometrically complex architectural project.

The different modelling experiments conducted through the thesis aim to facilitate and improve existing workflows by answering different research questions and validate several hypotheses, each one of them helping to draw the global picture of this speculative software platform. Each experiment attempts to answer at least one of those research questions:

- *How can a Multi-Scalar design framework allow the designer to work across the scales in order to take into account multiple constraints related to material, fabrication and structural performances at both early design and late stages?*
- *How can we reconcile "integrative computational design workflows" (an expression familiar to academia) with "segregated digital workflows" (a paradigm better understood by the industry)?*
- *How can we access, share, track, modify structured data within a common directory structure until completion of the building?*
- *How can we identify, access and communicate implicit knowledge spread across the unrelated leaves of the directory structure, multiple scales and different trades?*
- *How would an ideal multi-scalar parametric AEC-model look like and which requirements would it have to fullfill all user's requests? How could the multi-scalar model be interacted and which UI and UX concepts would be needed?*