No More Stopping

UNStudio,
Arnhem Central Masterplan,
Arnhem,
The Netherlands,
2015

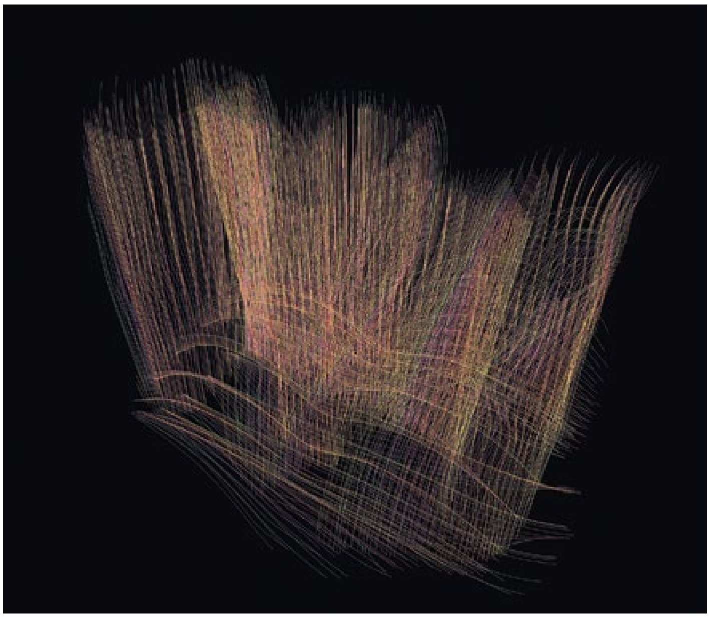
One way architects can remain engaged with their projects over time is by completing buildings originally conceived as part of a larger-scale masterplan, as UNStudio has done over the last 20 years for the Arnhem Central station. As part of a planning commission originally received in 1996, the firm has realised a bus terminal and underground car park, as well as a series of platform roofs for rail passengers.

The dissolution of the conventional breaking points in the construction and completion phases of a building's delivery has blurred 'the distinction between the production of design intent and the transmission of information'. Here **Richard Garber**, Director of the School of Architecture at the New Jersey Institute of Technology (NJIT), advocates that architects should use this as an opportunity to widen their remit, gaining agency and with it responsibility and the financial rewards to practice. Here he draws from the examples of UNStudio, GLUCK+ and his own New-York based practice, GRO Architects.

In the past architects have faced at least two stopping points: between design and construction, and at a building's completion. Recent advances in computer software in architecture have removed these stopping points, and so significantly expanded the role of architects and, as importantly, extended the period of time they can remain engaged with the projects they design. Stopping has long been an issue in architecture, inherent to practice. Where the stops are placed on a project both defines and limits an architect's time and operational territory. This has a qualitative as well as a quantitative impact. Allocation of time is synonymous with design quality, agency, responsibility and economic remuneration. For centuries, the stopping point was at the completion of a drawing set: how much information should the drawings contain was often a subject of negotiation between architect and client. Now, with the onset of the digital, there is no longer a distinction between the production of design intent and the transmission of information.[1]

From 1994 to 2004, animation software offered architects the chance to generate an endless array of tantalising formal possibilities, raising the challenge of when to stop and why. And, during that period it was difficult, if not impossible, for architects to move from forms achieved through animation to construction because both clients and builders were doubtful about the form's constructability, since the software being used for animation was not intended to guide physical construction. As a consequence, architects with digital ambitions used design competitions such as the Yokohama Port Terminal and Cardiff Bay Opera House to produce projects that were seen as remarkable but unbuildable. While notable projects were ultimately built, including the Presbyterian Church of New York by Greg Lynn FORM with Douglas Garofalo and Michael McInturf (1999), most remained exclusively exciting digital speculations, stopping at design and publication.

Then, auspiciously, the 4D and 5D tools of building information modelling (BIM), broadly adopted around 2004, allowed for continuity from conceptual design explorations through construction. Architects can now convey their design intentions virtually to builders, as well as a technological knowledge transfer to local contractors. Since about 2010, virtual models have extended architects' involvement even further by offering them opportunities to manage, evaluate and maintain a building throughout its lifetime. For example, UNStudio was part of a consortium that will remain engaged in the management and maintenance of the Education Executive Agency and Tax Offices building they designed in Groningen, the Netherlands, for a period of 20 years, at which point the building can be transformed into housing, a possible future that had to be conceived early in the design of the project.



Richard Garber,
Tower scheme,
Brooklyn,
New York,
2002

In the late 1990s, when architects used animation software for manipulations of geometry that allowed a form to change over time, it was difficult to judge why one form might be better than another. Those critical of such formal exercises called this the 'stopping problem'. In the scheme illustrated here, conceived while Richard Garber was employed at SHoP Architects, the towers were also colour scaled using an RGB formula coordinated with the amount of deformation.

UNStudio,
Education Executive Agency
and Tax Offices,
Groningen,
The Netherlands,
2011

UNStudio worked with a design-build-operate team not only to deliver the building, but also to maintain its operation for a period of 20 years following its completion in 2011. The decision to convert the project housing after two decades forced the architects to make long-term decisions about the design that would not usually be included in typical architectural services.

UNStudio,
Arnhem Central Transfer Hall,
Arnhem,
The Netherlands,
2015

Arnhem Transfer Hall is the central building in the Arnhem Central Masterplan that UNStudio has worked on since 1996. The architects created a data-transfer workflow to provide the glass-fibre reinforced concrete precast panel fabricator, mxB, with all the information they needed to invent a reconfigurable mould that was used to produce some 1,500 unique cladding panels.

Non-Stop Workflows

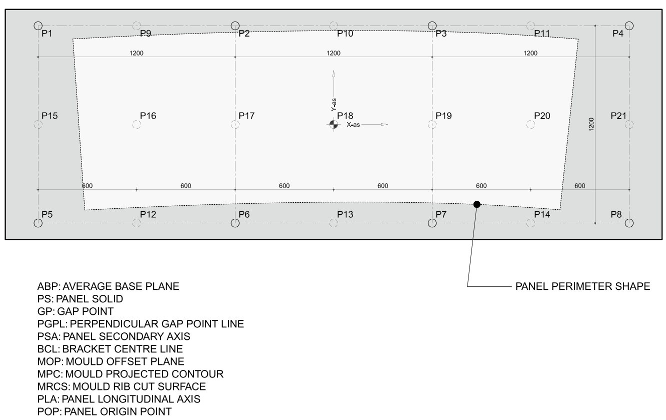
The advent of BIM effectively removed the barriers architects had previously faced when there was a hard stop between tendering contract documents by the architect and construction of the building by the general contractor. In this model, the architect had limited exposure to on-site construction processes or to those people involved in the fabrication of components and materials. In addition to the possibility of enhanced collaboration between the design and construction teams, architects utilising BIM tools can now realise continuity through the organising of virtual data (including geometry) – performance simulation – through the fabrication of building components, project scheduling and transmission of data for construction.

As BIM is a graphic database of the architect's design intent and the geometry and building components it informs, architects working in the 21st century have become increasingly sophisticated in the way they manage data and its flows to others on the design and construction team. From its beginnings as a concept in the manufacturing schemas of the industrialising world, such workflows not only define a related scope of work between parties over time, but also increasingly include specific ways in which these parties interact.

UNStudio has built itself around several core research platforms that redefine how an architect's design intentions fit into an overall project workflow, as exemplified in the Arnhem Central Transfer Hall (2015). The hall is the principal piece of the Arnhem Central Masterplan, which UNStudio completed in the late 1990s. Realising individual buildings, originally conceived as parts of a planning project, over the course of 20 years is certainly one way architects can remain engaged with their projects over time.

This view of the roof shows the tolerances the precast fabricator was able to achieve using the reconfigurable mould.

UNStudio generated a series of VisualBasic scripts within Rhinoceros 3D modelling software to extract dimensional data from the series of 21 points for each panel. The data was transmitted electronically to the installer, Sorba Projects, who added further information for the substructure. The dataset was then sent as a comma-separated values (.CSV) file to the precast fabricator who used laser projection and a series of magnets to reconfigure the casting mould to produce each specific panel contour and perimeter shape.



Working closely with UNStudio, the panel fabricator, mxB, devised a reconfigurable mould that was constrained by 21 individual points that were adjusted by measurements taken from the architects' Rhinoceros model. Among the various dimensions required by the fabricator were axis points, contour offsets and perimeter shape conditions that UNStudio provided in a spreadsheet.

For the design of the hall, UNStudio worked very closely with the fabricators and installers, utilising their design model directly in the fabrication process of the roof panels. In this case the designers found a creative way to engage the precast subcontractor directly through the transfer of information from their model. Here, the design model was not simply used for the tendering of documentation, but was extended directly into the fabrication process through data extraction, which in turn produced a flexible mould system for the building's glass-fibre reinforced concrete roof panels. This case demonstrates how the variations explored in the 1990s through animation can now be quantified and specified for fabricators. Geometry was always precise and measurable in the computer. Now, through data translation, it is buildable.

The Arnhem Central Transfer Hall links distinct transit modes together in the railway station complex, including pedestrians, trains and local and regional buses. A large car parking garage exists below it, and two office towers sit above, giving the west side of the building a fairly rigid gridded layout that is intertwined with the east side where all the various transit modes come together. During the planning phase, the building was imagined as a concrete shell with some steel trusses. However, following the document tendering, the contractor, Bouwcombinatie Ballast Nedam, proposed a steel roof structure with a glass-fibre reinforced concrete cladding. In working with the contractors, UNStudio rationalised the structure and were also able to determine how to make the panelling more feasible and cost-effective.

In rationalising the panelling system, a workflow was invented that would seamlessly transmit precise digital sizes and dimensions from the design model to the fabrication beds of the fabricator. UNStudio worked with mbX, an innovative precast company, to create a series of scripts that would extract the necessary data from their Rhinoceros model and format them in a spreadsheet for the fabrication team to use. This workflow allowed for 98 per cent of the approximately 1,500 panels to be formed in a flexible mould that contained a total of 21 point locations, and was hydraulically adjusted and held in place with magnets to achieve the various panel shapes. The extraction of information and the invention of the flexible mould were novel, yet the instructions to build were quite simple. These operations pre-empted a stop in the flow of information between the designer and the subcontractor. Sorba Projects, a facade engineer and installer, engaged mbX in the fabrication process and installed the panels on the building's steel frame.

In this project, as in many projects where BIM is employed, there was no stopping between design and fabrication, in that the information model, first as a design model and then as a fabrication model, provided all the data necessary to go directly into fabrication and no tendering of shop drawings or other production was required. The design team wrote tools in VisualBasic for Rhinoceros 3D to extract specific data and measurements from the model for the flexible steel mould system. No geometry was transmitted to the fabricators, and in effect the data went directly from model to mould.

Building+

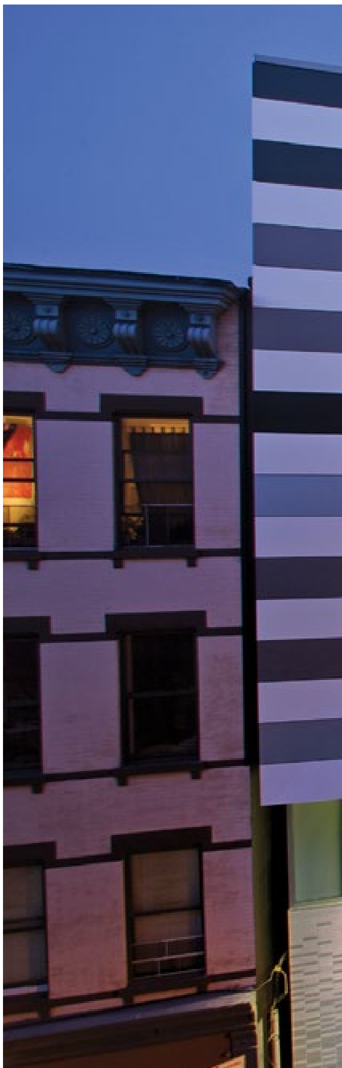
BIM allows for enhanced collaboration between the architect-led design team and the construction subcontractors while the building is being constructed. Data conceived using BIM during the design phases can subsequently provide information for monitoring a building's performance after it is completed. The question then arises: Who makes decisions based on a reading of that operation data? The architect is certainly one candidate for that role.

And indeed, architects, or at least the virtual models they develop in the service of the design-to-construction process, have found an afterlife in the world of life-cycle assessment and management (LCA+M). Increasingly, these models are being used to manage buildings over time, often in their daily operation. Such monitoring can occur for relatively short periods, such as a year or two to ensure proper commissioning of the mechanical system, or over longer periods that may coincide with a 20-year or 30-year financial agreement.

Large teams of designers, builders and operators are now participating in the execution of design-build-operate (DBO) contracts, which are becoming increasingly popular in the US and Europe for institutions such as universities and government agencies. Under such agreements, a private-sector team provides design, construction and operation services under a turnkey contract that includes provisions for the operation of the building over a period of time. These agreements emerged in the early 1990s as public-private partnerships (PPP's) for large-scale infrastructure projects such as roadways or ports. However, the ability to simulate physical capacities of buildings, such as their energy consumption or lighting

GLUCK+,
The East Harlem School,
New York,
2008

During the post-occupancy calibration of the building's mechanical system, the school board decided that, to reduce costs, the system should be simplified so as not to heat or cool the building in the spring and autumn. About two years after the building was occupied, the system was retrofitted to allow for fresh air without the requisite cooling and heating, and the cost savings have been significant.



output, within a BIM makes it useful at the operational level of smaller-scale buildings as well. In effect, BIM transitions from a design tool to a construction tool to an operational one.

Peter Gluck uses an analogue version of BIM, which he calls Architect-Led Design-Build (ALDB). He has been outspoken about the traditional divisions between architecture and construction and how post-occupancy is understood. His firm GLUCK+ regularly enters into contracts to both design and build their projects, and is increasingly involved in the operational activities of their completed buildings in the years following client occupation, becoming an example of a DBO architectural practice. Since the design team leads the entire process, from concept to construction completion, team members can analyse, interpret and respond to post-occupancy issues with immediacy.

ALDB has allowed Gluck to stay involved with projects beyond the traditional point of drawing tender. He does this for the success of the project, achieving better design at lower cost through the coordination of individual building trades and construction sequencing. In the case of the East Harlem School, this process allowed the project team to forgo use of funds allocated for construction contingency while bringing the final cost of construction in at US$500,000 under the guaranteed maximum price, which was then applied to the school's endowment. Given the success of the project, Gluck was invited to join the school's Board of Trustees, and he continues to be involved in its post-occupancy operation. He pursues this role with institutional projects as well as individual houses, and maintains professional relationships with clients in both cases.

Better design at lower cost through the coordination of individual building trades and construction sequencing

In 2005, GLUCK+ designed and built the Bar House in the Colorado Rockies, and then a guest residence, the House in the Mountains, on the same site in 2014. The guesthouse incorporates an intricate solar hot water system that heats the pool during the day and the house at night. Through metrics and remote monitoring, the design team realised that the solar hot water system was not working as efficiently as it could post-occupancy, leading them to set new benchmarks on the system's thermometer. Charlie Kaplan, the project architect for GLUCK+, conceived a thickened wall of millwork that the solar hot water panels would clad on the south-facing 'service side' of the project, providing an accessible cavity for the plumbing system.[2] The system is a 'drainback system': rather than taking hot water into a service tank, it is injected directly into a hot water loop that feeds the swimming pool, living space and hot tub. The team wanted to circumvent the use of the boiler so decided to programme an override into the system. On sunny days, the solar hot water system would continue operating to heat water up to 30°C (86°F), so at night the water temperature of the pool would not fall below 28°C (82°F) and force the boiler on. In effect, the team found that overheating the pool, while still keeping it within the comfort zone of swimming, would deliver energy savings in that the boilers would not be used during the summer months.

During 'normal' design or construction stages, it would have been impossible to understand such intricacies in the way the solar hot water system and boiler would work together. The solution came post-occupancy through the architect's understanding of how the clients were using the system and when they were using the pool. Gluck refers to this post-construction responsibility for a project as 'staying with these buildings', and gives each owner an operational manual of sorts that is produced six to eight months after the building is occupied. According to him, this is 'defensive on one hand as most mechanical systems don't work quite properly when first commissioned'.[3] The conventional solution is to bring in a third party, typically a mechanical subcontractor not previously involved with the project, to 'fix it', which further complicates what is generally a problem of 'dialing the system' to get it to perform as designed.

This example also reveals the degree of coordination many architects are beginning to require in the execution of work. GLUCK+, as architect, facilitated collaboration between all parties who worked on the pool system: a plumbing subcontractor, a controls subcontractor, a control system manufacturer and a mechanical engineer. The high level at which the mechanical system now performs would have been 'impossible to achieve on the front end' according to Kaplan.[4]

GLUCK+, House in the Mountains, Colorado Rockies, 2012

The swimming pool created a large heating load, and it became clear once the house was occupied that seasonal strategies would need to be implemented to optimise the solar hot water system. Colorado has a very specific and varied climate. In the summer the heat load on the living spaces is minimal, so there is no benefit to the system in terms of heating them in the summer months.

The south-facing 'service side' of the house has automobile access to the garage as well as a cavity wall outfit with solar hot water panels that heat both the living spaces of the house and the pool.

Prior to the late 1990s, architects could expect only limited involvement during the construction of their designs, creating a disconnect of the architect from the construction site and marginalising the architect's role within the design and construction process. With the initial invention of computer-enabled design, architects were able to propose projects that piqued the interest of potential clients, but were not easily buildable. BIM has not only made construction of such works possible, but has allowed architects to play what is now a far more central and necessary role in managing both design and construction data between numerous parties. So there is no stopping between what had previously been discrete stages of designing and building. With the more recent advent of DBO schemes, architects can now engage owners and facility operators in post-construction actions to ensure that buildings perform, and continue to perform, as designed.

It is crucial that architects understand the opportunities such actions present. They extend our agency while allowing us to expand the territory of our work. No longer does design stop when the 'drawings are done' or even when the building is completed. We are entering a period of non-stop architecture. ◊

Notes

1: Richard Garber, *BIM Design: Realising the Creative Potential of Building Information Modeling* (John Wiley & Sons (Chichester), 2014.

2: Conversation between the author and Peter Gluck, Charlie Kaplan and Stacie Wong, New York, 20 May 2015.

3: *Ibid.*

4: *Ibid.*

right: The wall cavity on the southern site provides a canted surface for the mounting of the solar hot water system that heats the interior spaces, spa and pool. The resultant triangular cavity contains all the piping to supply hot water to all areas in the house. The interior abutting the cavity is fitted with a wall of millwork, which provides storage. Finally a continuous clerestory window, fitted with a light.

below: The solar hot water system is used primarily to heat the swimming pool to a comfortable temperature during the summer. The nighttime air temperature can drop to 7°C (45°F), causing the pool to dip below its set point. The mechanical system's boiler automatically turns on to compensate. With a fine-tuning of the controls of the solar hot water system, the heat is stored from the last hours of sunlight in the late afternoon to heat the pool by a few degrees the next morning.