Remote impressions: roboformed prototypes for a nomadic studio

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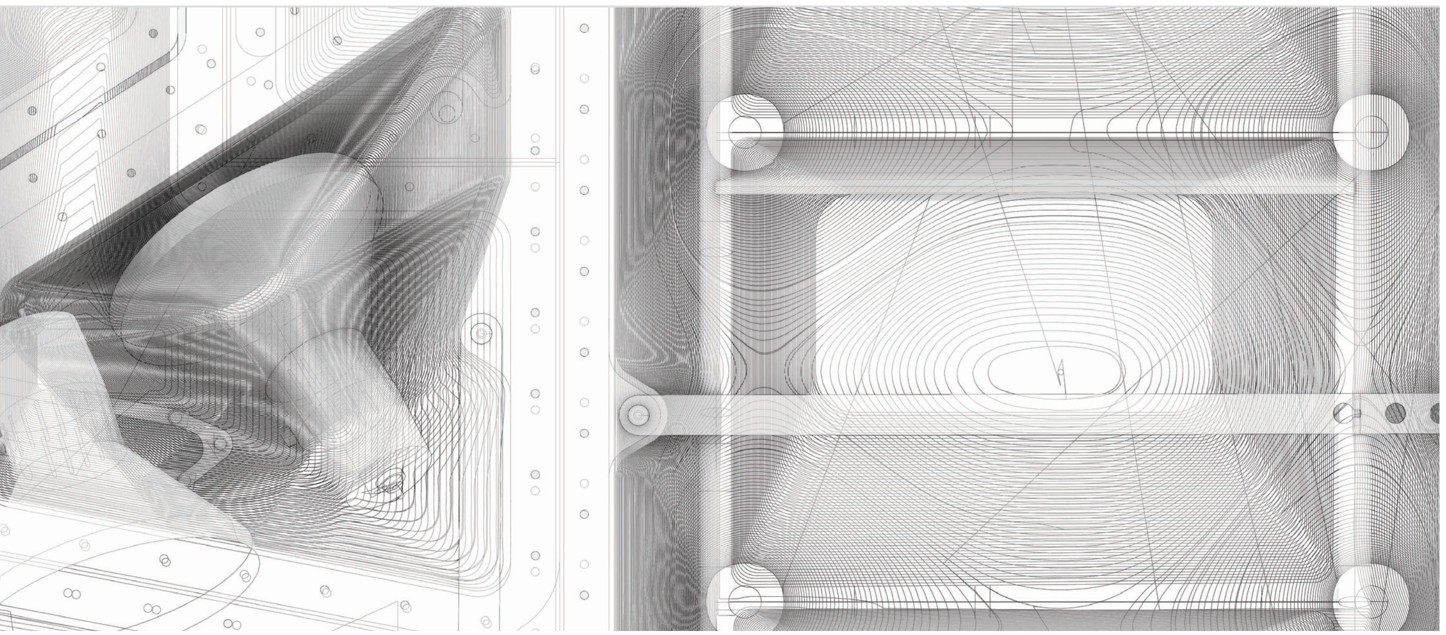


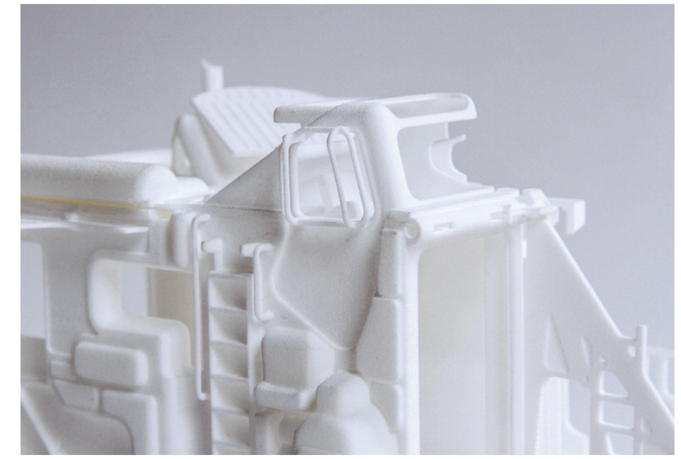
1 SPIF toolpath overlay of both skins of the prototype wall, showing the transformation between interior and exterior ladder.

Someone walking past the robotics lab, seeing the steel panel with the shape of a chair pressed into it, asks us how we have managed to vacuum-form steel. The chair belongs to James, we explain, the sculptor with whom we are designing and building a mobile artist studio. James has become famous for making fantastically absurd sculptures – he is just finishing a boat that will pull itself up the bank of the Thames, inspired by the comical amphibian mudskipper after which it is named. Like all of James' sculptures, it actually works.

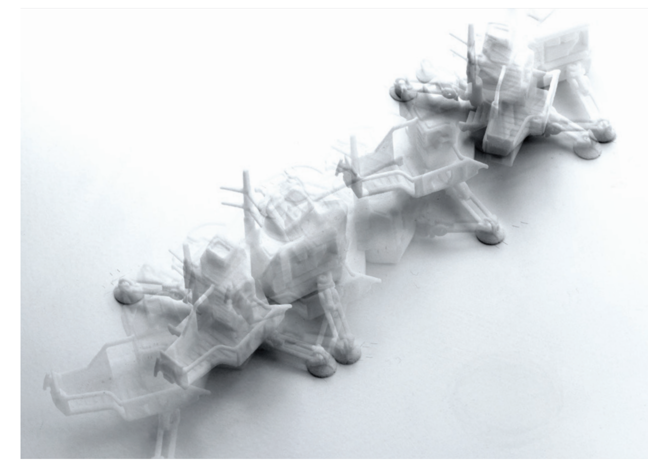
Now we are collaborating on the next amphibious sculpture inspired by lizard locomotion. The chair is one of many objects that will come on its expeditions and will be stowed away into the wall of the extremely compact studio. We picked the old-fashioned piece, with its leather upholstering, turned legs and backrest stiles because it conjures up images of Admiral Nelson´s chair on the HMS Victory – only that now, in an odd hybridisation of pre-industrial and post-industrial manufacturing processes, it is 3D-scanned and robotically formed.

All of the 50+ panels of the 1:1 prototype wall that we are currently building are fabricated using robotic Single Point Incremental Forming (SPIF). But it is whilst prototyping this chair panel, with its awkward geometry and challenging depth, that we tear the most sheets, blunt the most end effectors – and consequently learn the most. We learn that the flexible timber framework backing the panels, which we developed because it was quick, cheap and variable, had the added advantage of yielding to forces, which compensates for the more unforgiving material constraints of the sheet steel we are forming. We learn that, as the robot gradually presses the panel into shape, the timber sub-structure tends to creak like an old sailing boat. We learn that our end effector should equally be softer than the material it is forming and finally settle on a brass stylus, which we have to sharpen like a pencil between forming.

Because the chair is difficult (and perhaps slightly silly), because it tells the fabrication process what to do rather than just listening to what it has on offer, we learn how to analyse and optimise formable geometries: filtering the



2 The thick wall of the artist studio (photograph by Greg Storrar).



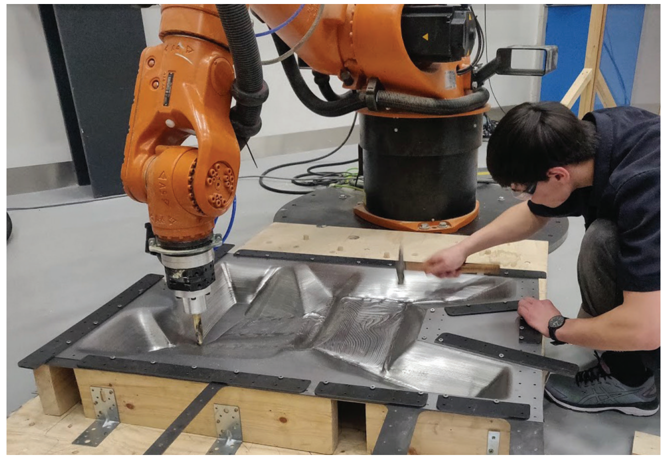
3 Overlay of studio locomotion (photograph by Greg Storrar).

4 A difficult chair (photograph by Thomas Pearce).

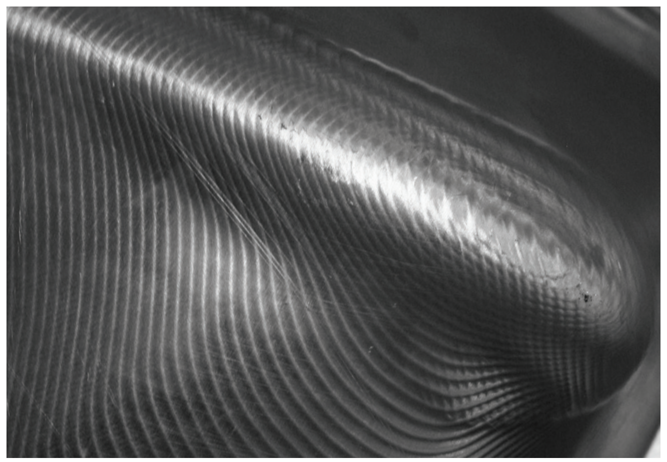
scan according to draft angles; smoothing and relaxing the mesh; modelling the surface between the scan and the edge of the formable surface according to allowable geometrical constraints (many quantifiable, many intuited) for robotic forming. We learn to generate toolpaths that minimise the common SPIF 'pillow effect' and continue to battle what we call the 'pinching effect', an extreme case of pillowing that appears specifically at the point where the long valleys around the chair's legs close in on themselves and accumulate (or 'pinch') excess material.

Our dialogue with the chair, or rather the dialogue between the chair and the sheet with us as mediators, becomes more interesting when more voices join in. A conversation between the studio's two skins unfolds. The exterior 0.9mm steel skin is riveted onto a structural frame (the very same frame we use for forming, with a set of standardised clamping plates, to secure the blank panels in the first place) whereas the interior 0.9mm aluminium skin is hung, thermally separated, from the load-bearing exterior frame. The conversation between the two skins is marked by transformations and productive mistranslations: an axe head inside offers a boot scraper outside; the swing of James' knee, sitting at his desk on the inside, presses into the aluminium skin, the knee cap traced by a secondary toolpath expressing the patella structure, and translates as a bulge on the outside, where it is used as a leg-up to climb an exterior ladder and access the studio's roof. A secondary dotted pattern, added to the upper leg, provides extra grip to this step. The inner sitter helps the outer climber.

Without touching, through the mediation of the thick in-between of the physical wall, of the digital modelling process and the material and robotic fabrication constraints, the two skins modulate each-other, resulting in strange hybrids. The exterior ladder, for example, echoes a moveable ladder on the inside, transforming the intersection of its treads and stringers to form three pairs of circular protrusions, 'nipples' that accept the bent rungs for the exterior ladder. Below these nipples, another knee emerges, which, rather than an echo of an internal knee, follows the



5 Digital and analogue forming of chair (photograph by Thomas Pearce).



6 Interior knee with patella toolpath (photograph by Thomas Pearce).

7 Capper with prototype wall and interior ladder (photograph by Theo Tan).

need for an additional step between the first knee and the first rung. The ladder's knee is the deepest and steepest piece of forming we do.

We have nearly forgotten the person who had prompted our train of thought with the initial question about the chair panel – and who is still listening, though seeming slightly puzzled about how the conversation has moved from a timber chair to walls growing nipples and ladders begetting knees. Perhaps the project's conceptual framework has escalated? But then again, perhaps by doing so, it has continued to challenge us as digital makers? And perhaps, within the cross-contamination between bodies, objects, skins and code, another type of knowledge has emerged – a hybrid knowledge? In the background, the creaking boat sound grows louder and louder, it is time we sharpen our brass pencil.

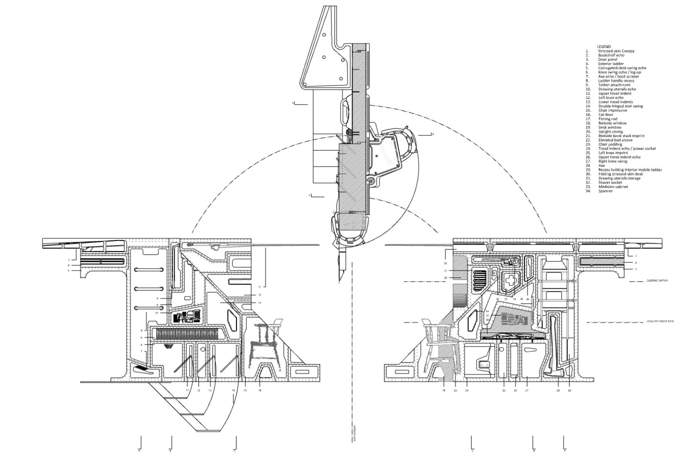
ACKNOWLEDGMENTS

Monitor, the mobile studio discussed in this piece, is a project by James Capper, Thomas Pearce and Greg Storrar.

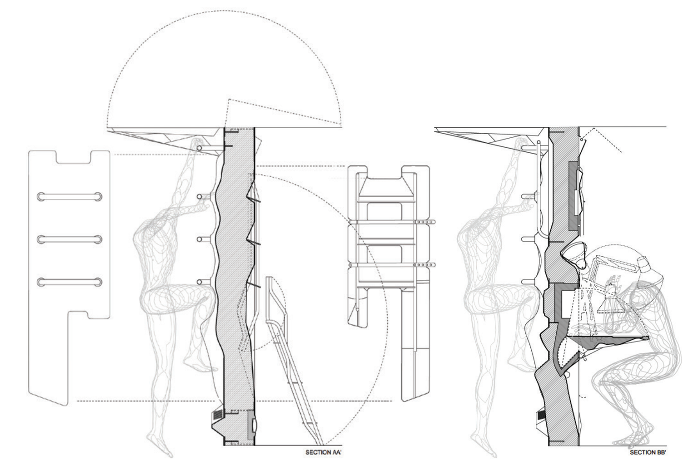
The team at The Bartlett School of Architecture (University College London): Thomas Pearce, project lead, design; Greg Storrar (ARB) design; Gary Edwards (ARB), robotics; Theo Tan and Cristina Garza Lasierra, research assistants.

This project is made possible thanks to generous support from the Higher Education Innovation Fund (UCL Knowledge Exchange grant), the Bartlett's Architectural Project Fund, Hannah Barry Gallery (London), Izolyatsia (Kyiv) and Tata Steel. Many thanks to the staff at B-Made for enabling and supporting our research. The robotic incremental sheet forming in this project was initially based on a research project developed by Cristina Garza (DfM) in collaboration with Vincent Huyghe of B-Made

8 The exterior ladder's leg-up knee (photograph by Thomas Pearce).



9 Unfolded elevations and plan, showing translations between two skins.



10 Cross-sections illustrating bodies transforming through the two skins.

IMAGE CREDITS

Figure 1-3: © Greg Storrar

Figure 7: © Theo Tan

All other drawings and images by the authors.

Thomas Pearce is a Lecturer at the Bartlett School of Architecture, where he currently teaches in the MArch Design for Manufacture programme. His collaborative design research practice straddles the boundaries between architectural design and fabrication, historical reconstruction and speculation, performance and technological subversion. He has worked extensively in practice as a specialist for digital capture, design and fabrication. Thomas holds a BA and MA (KULeuven, Belgium) in Cultural History and a BSc (TUBerlin) and MArch (Bartlett) in Architecture and is currently finishing his PhD thesis in Architectural Design at the Bartlett.

Gary Edwards is a Chartered Architect, researcher and computational designer. Having studied at the Bartlett (Unit 23) he is no stranger to analogue and robotic methods of fabrication. He works closely with Free and Open Source communities developing bespoke design tools that bridge digital and physical realms. He worked a number of years at the global engineering firm Arup where he was Software and Tools Leader for Architecture.He has taught at the Bartlett and AA Schools of Architecture as well as into industry. He currently runs his own consultancy and design practise.