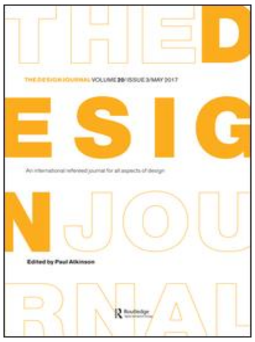

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Entropy: Unpacking the form through post digital making

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Abstract: Creative processes in architecture are traditionally dominated by the mediums of sketch and model. The contemporary landscape of burgeoning digital concepts and fabrication often dominates the making process, despite our claim that there is no 'digital design', because of the absence of iteration and interpretation within a hermeneutic cycle. The focus of this project is to investigate 'digital design' through the juxtaposition of a human driven and digitally supported creative process. The outcome is a series of objects of 'Entropy', that investigate the interaction between creative intention, digital processes, real materiality and space. Through this we simultaneously bring to centre stage the urge to control form and materiality in an automated manner, and the obfuscation of the creative process via technological error/serendipity or haptic play. This is an investigation of the post-digital future of design, of the merge between design intention/intuition, digital media, craftsmanship, experiment and object.

Keywords: play, experiment, post-digital design process, tactile intuition

1. Introduction

'Digital Design' is a common phrase in contemporary creative industries. This paper draws upon original design research to unpack and contest its meaning. This paper is an excerpt from an ongoing PhD investigating the relationship between emerging digital tools and processes within contemporary design. It argues that the popular conception of digital design is perhaps more accurately described as digital fabrication or digitized concepts (Menges 2012). 'Digital design' as described by Snodgrass, Coyne (Snodgrass & Coyne, 1997) and Lawson (Lawson, 2006) is a more complex and illusive proposition that involves iteration, accident and exploration.

Figure 1. Entropy, sculptural work installed in a retrofitted Industrial space in Sofia. material: laser-cut brass 0.5- 1.00 mm, size 12000x800x4500mm

We begin with a short review of architectural design process, which is littered with conceptual drawings, models and rich textual narratives (Lawson, 2004, 2006). Currently the industry latches onto various digital fabrication technologies such as 3D printing and robotics (Kolarevic & Klinger, 2008) - as they hold the promise of greater integration between design and delivery (Owen, 2010), and thus control of material outcomes. They challenge the existing traditional tools and processes and render them slow and ambiguous. We see a new trend of architecture under various monikers such as 'digitally sponsored convergence' (M. Burry, 2005). This trend arguably takes architecture and design back to its pre-renaissance historical roots; the architect as a master builder ['architect' gr. master builder, arkhiteonikos; 'mere craftsman' (Coyne, 2011, p. 33)]. It can also be anecdotally referred to as 'robot porn', a phrase which dismisses the phenomenon of extreme digital design and fabrication as a mere spectacle; as titillation or folly. In the media these processes are rendered as seamless, the architect no longer appears to need a team of project managers, builders and engineers to produce architecture in real scale – a robot is sufficient. Thus an illusion, or cultural imaginary, of the architect in total control of all design and materialization processes begins to take root. No longer limited to design through sketching, modeling or even rendering to provoke the imagination of clients or themselves; designers can produce the architecture directly (Bernstein & Deamer, 2010, p. 73). Although digital design holds the promise of liberating designers from being relegated to observe how others interpret and realize their creations, this short review of the design process brings forth the following:

- Contemporary digital design is more accurately described as digital fabrication. The process is one directional and it is predominantly product oriented.
- Craft remains in the digital design process (Davis, 2013) although machines, code and processes also accompany the crafting or design of the 'thing.' The coding is the shortcut needed to overcome repetitive tasks. On the other hand the horizon of

possibilities is limited to the digital competence of the designer or the size of the design team.

- Current digital design appears to marginalize the opportunities found within play (Wittgenstein, 1953), dysfunction (Wiszniewski, Coyne, & Pierce, 1999) or the performative (Thrift, 2005) and privileges 'correctness.' The process is closer to engineering and construction, than to a creative intuition driven experimental workflow.

Thus we contend the terra incognita - the making of architecture, the 'craft in architectural design' (Davis, 2013, p. 49) remains largely realized through manual design techniques due to their propensity for iteration, rejection and evolution. The last hundred years have seen the sketch, discussion and model established as the authoritative vehicles for exploration, inquiry and design, as

Figure 2. Entropy, artefact # 31, material: laser-cut brass 0.5mm, size 450x600x450mm

defined by outdriving modernist language and practice (Forty, 2000, p. 21). Digital design, however, as currently practiced, is the precise robotic fabrication of complex forms. This creates a disconnect between the architectural tradition and the current digital design trend.

Returning to our research, the project 'Entropy' (figure 1-2) described in this paper is an enquiry into hybridizing both the forgotten playfulness (Wittgenstein & Anscombe, 2003) and its experimental shift through digital and analog. It is a self-reflective analysis of a creative process driven mostly by an urge for direct interaction with materials, but influenced vastly by the restrictions and possibilities of digital media and provided workflow. In this experimental work we try to recover the human driven aspect of being an intuitive creator (Picon, 2010, p. 60) without neglecting the technological advantages of the available digital tools. The digital craft and the real material tactile interaction are the two logical threads explored in this project. The focus is set on how they support or prevent the designer in taking design decisions. This aims to explore a post-digital process by reclaiming 'the interpretation of digital capacities into cultural production ' (Colletti, 2007, p. 212). It is an exploration of a personal creative practice led by the belief that 'all skills, even the most abstract, begin as bodily practices … that technical understanding develops through the powers of imagination' (Sennet, 2008, p. 10).

1.2 Methodology

We use what Downton calls 'research activity'; examining ways of doing things.' (Downton, 2003, p. 20). The research is technique related and reflects on design as experiment, with all implications and obstacles. It is an exploration into the messiness and inconsistent nature of creative process 'precisely because it has to negotiate a reality that is itself messy and inconsistent'(Allen, 2009, p. xii).

Figure 3. Design process artefact # 29 under manual manipulation

By way of a theoretical framework for the analyses of digital design we use Lawson's widely accepted conceptualization of design as a repetitive cycle of analysis, synthesis and evaluation that moves a designer in stages - from a problem space to a solution space (Lawson, 2006). Every cycle is created through the failure or success of a series of 'opening possibilities' (Bergson, 1992, p. 21). In the following sections, we will discuss the three stages of Entropy's design: *beginning, making* and *realization*, before finally summarizing how digital tools affect and disrupt the design process.

2. Entropy – The Beginning

It has been theorized that architectural creative practices are born out of a material based work, but later shift into the discursive (Allen, 2009, p. xiii). Now, through digitally sponsored fabrication, creative processes are again returning to material practice (figure 3 and 4). By way of an initial design challenge, we started experimenting with the concept of how to maximize the space that can be enclosed by a sheet of paper, card or textile. This was achieved by manually and subsequently via laser-cutting complex patterns onto the material thereby allowing it to expand. The technique is a common procedure that can be carried out manually with a sharp knife or digitally by laser-cutting. A series of questions arose: How to control the rigidity of the end artefact, how to control the

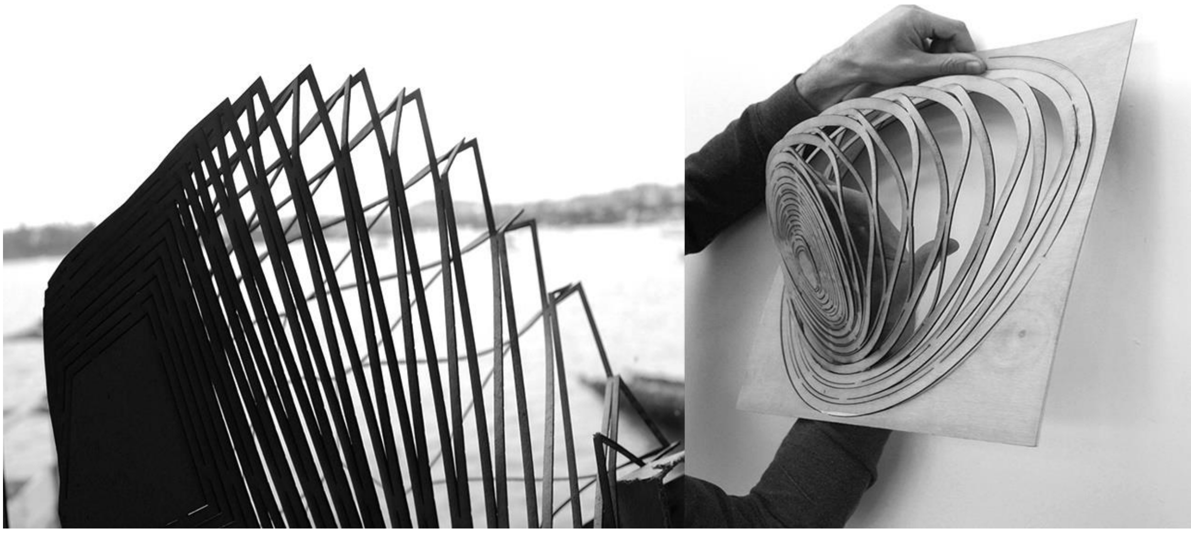

Figure 4. Left: Design process artefact # 3, material - cardboard // Right: Design process artefact #15, material - plywood

maximum and minimum force for manipulation before the material collapses, how to predict the resulting form based on the initial parameters of the laser cut pattern. We theorized that beginning with a technique that afforded a democratic design process would neither privilege nor marginalize digital or manual techniques. At this stage, the process was not driven by a traditional design brief. The motivation behind this experiment was the creation through digitally driven tools and objects, which appears random and handcrafted. We initially wanted to achieve a seamless process as in the current world of 'digital design', without hiding the tool and the reason for the outcome.

2.1 The hand

The first artefacts were manufactured using a laser cutter. First the laser cut pattern was drawn with simple computer aided design (CAD) software. The urge for more freedom led us to experiment with variety of random shapes as a basis for the pattern. This led to the eventual adoption of Grasshopper, a powerful parametric and procedural design software. This allowed us to automate the preparation of the CAD file for laser-cutting. To prepare the file by manually drawing the pattern in CAD software took approximately one hour, using Grasshopper the preparation took a minute per artefact. The speed of iteration and ease of production enabled us to start thinking in terms of material practice and quickly test mechanical properties in a physical manner. Although several of the prototypes fell apart in the laser bed, some broke while manipulated, and many ended in the trash due to a lack of excitement from both their aesthetic and mechanical properties. Nevertheless this enabled us to learn about the benefits of this physical play as conceived by Wittgenstein

(Wittgenstein & Anscombe, 2003); exploring the opportunities at the boundaries of possibility. At this stage of the process physical changes to scale, size and material stiffness had a significantly greater influence on the object and creative process than the possibility for digital control. Engineering correctness could not be achieved due to the complexity of variables involved: mechanical forces, stiffness and an extremely random dynamic end result.

2.2 The robot

To achieve a repetitive manipulation set up and to limit one of the variables we organized a workshop with undergraduate students, assigning them two distinct tasks (1) to 'play' with the

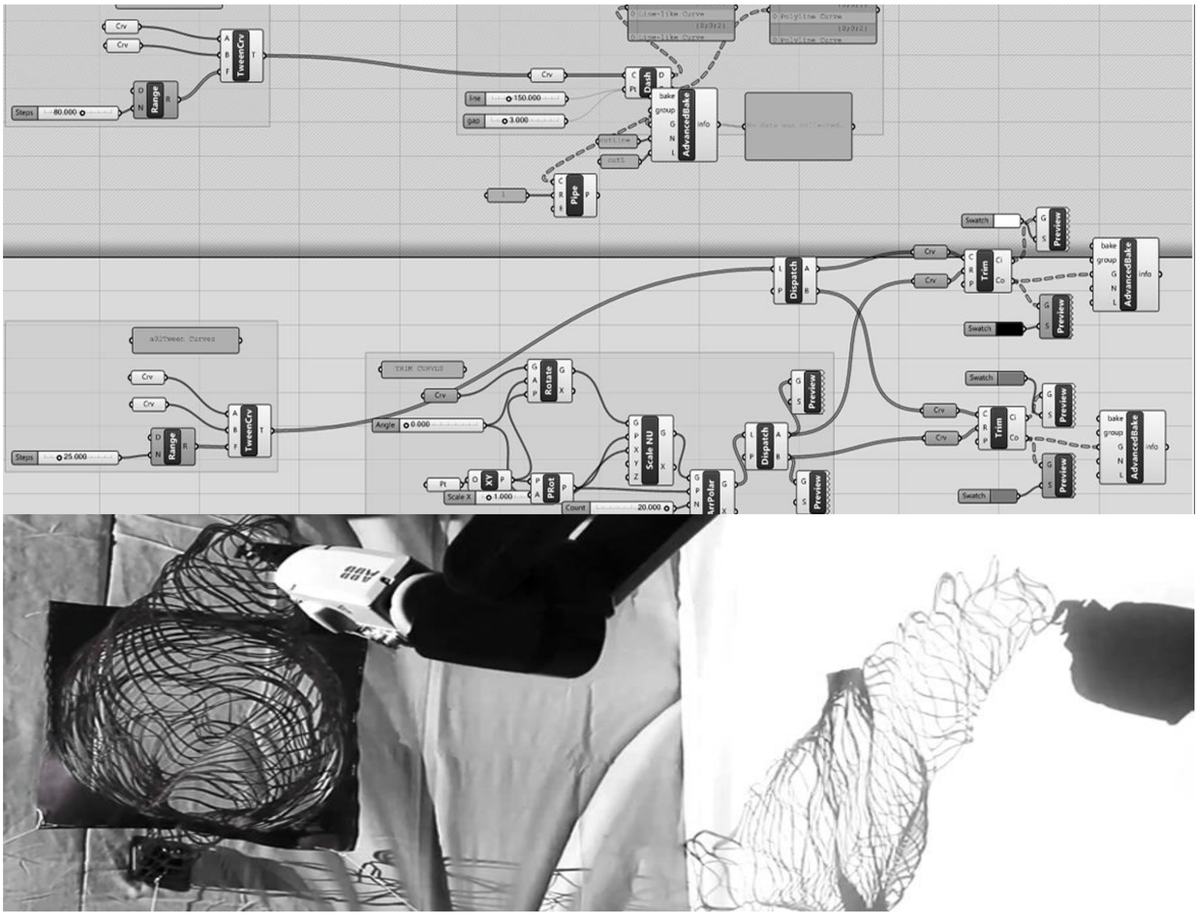

Figure 5. Design process Grasshopper script, artefact # 28 and ABB Robot. Robotic movement and end effector experiment

grasshopper script and produce a set of experimental patterns and laser-cut prototypes and (2) document the transformation and dynamic possibilities of them first manually and then using the school's industrial robot. The robot hand manipulating the object eliminates the option for playful experimentation, nevertheless a degree of sacrifice was necessary inside in the search for 'digital correctness' in design. The results of the week-long workshop demonstrated that the design challenge and process was interrupted by the dominance of parallel design challenges. An objective set of new technical processes emerged such as designing and making end effectors for the robot to hold the material; generating, testing and debugging complex toolpaths to manipulate the material in ways that offer additionally over manual handling and manipulation (Figure 5).

This was the initial hermeneutic loop, the first step into the creative experiment. Playfully testing different materials and techniques, and progressively increasing the presence of 'digital' design processes. An analysis of this first cycle of design revealed the greater the complexity of the digital tools, the greater the disconnection to the material investigation of the actual artefact being designed. At that stage it appears to be impossible for to change the scale of the experiment following our digitally true strategy. However we must also recognize that the considerable freedom the designers had at this stage is a constraint in itself. The object was missing key architectural parameters, what Antoan Picon calls a crises of scale (Picon, 2010, p. 125). To sum up the experiment till that point failed to be both truly playful and architectural, despite keeping its digitally driven character.

3. Entropy – The Making

3.1 The context

> ‘They lack the disciplining characteristics of a site. (…) the lack of constrains is, for architecture, a constraint in itself. Architectural design has historically used the context as a determinant of organization and form. Its absence is a difficulty as much as freedom.’ (Salinas, 2009, p. 24)

Entering the second cycle of design it was recognized that digital media and virtual space tend to lack the notion of scale, context and create a disconnect to the human body. During the first cycle of design these affordances helped to support a playful exploration of design in an abstract way. During this second phase of the project we were, separately, commissioned to redesign a 200 sq. m. space in an industrial building in Sofia, Bulgaria. This resulted in the application of our experimental design work to this space; it provided both scale and context to further develop and test the architectural value of our, as yet, abstract proposition.

3.2 The obstacle tectonics

The first limitation of digital design was revealed when trying to communicate and inspire the client with the idea of a large scale installation. The formal possibilities that are demonstrated through manually playing with a physical model engaged them more directly that the digital model. Following this initial discovery we produced a series of paper prototypes 400mm x 400mm in size, these were used to discuss and convince the client to pursue the idea of large scale digitally crafted unique object of random geometry. Here, the discourse was predominantly through real material prototypes.

It was envisaged Entropy would be eventually fabricated from metal. The second limitation of digital techniques within the design process was predicting mechanic properties and material limitation of the different types of metal that were available to us. Due to fluctuations in both budget and production time the project faced changes on a daily basis. This resulted in the material choice for the installation transitioning from steel to copper and finally to brass. Each material was available in thicknesses from 0.5mm to 4mm. Our attempts to test the material properties on the digital model in Grasshopper were unsuccessful. It was not possible, without significant engineering expertise, computing and programming skill, to use Grasshopper in a meaningful way within the design process to predict the behaviour of the material. At this point we shifted away from the artefact design process and sought expertise from the craftsman. We sourced materials, discussed and sketched with local craftsman and technicians, and made some limited brass prototypes to test assumptions (figure 2). Here manual techniques necessarily took precedent within our digital design process. Perhaps allowing what Coletti has described as ‘playful, unbiased attitude’ (Colletti, 2013, p. 216).

This marked the end of the second cycle, where the artefact generated from the initial cycle was put under a manifold of pressures from both the client and the demands of the design process. The need for special skills, in this case engineering prowess, to implement a dynamic digital model did more than limit the design possibilities, it reframed the design process. We were no longer exploring the performative (Thrift, 2005) of the object in its abstract or material state. Instead the concept of the model being 'right' was now centre stage. The urge for sophisticated automated material control of the material physical nature of the object through a digital model became a creative constraint rather than opportunity. To implement such a model requires engineering calculation, the purpose of which is to avoid failure.

The very politics of this engineering phase regards failure and dysfunction negatively and obliterates their design or creative value. This politic is further amplified where digital tools are used, where seamless and smooth experiences are the measure of success. At that stage we gave up the miraculous nature of digital design and its seamless unlimited coding power. We decided to sacrifice digital correctness for creative playfulness.

4. Entropy- the realization

4.1 The obstacle - fabrication

After overcoming the stress of digitally non predictable material tectonics and left the attitude of surfing data (Connah, 2001), we began the third and final cycle of design, the on-site realization. At that point we did not know what the object would resemble at the very end, the failure of the digital set up annihilated the option of designing a result.

Figure 7. Entropy, onsite realisation. Structural and mechanical failures and challenges. Problem solving on site

Unexectedly the laser-cutting facility being used to cut the brass was overbooked with morelucrative projects. Another iconic cultural imaginary of the digital design and fabrication was about to be eliminated- the seamless connection between digital design and fabrication. We had to use an alternative facility, run on outdated computer aided manufacturing (CAM) software. Although it was more than adequate for day to day work, it was not obviously compatible with our digital workflow and the complex laser cut curve. The avoidance of failure with regard to design, digital tools and materialization was again brought to centre-stage. The specialist manually redrew the pattern. The intention of producing eight slightly different 'mutations' of the original prototype and so creating a unique 'handcrafted' object was not possible due to the lack of direct data transfer between Grasshopper and the CAM software. The need to redraft each of the patterns was neither economical nor logical.

4.2 The play – onsite

The final stage, setting up the installation on-site, accidently broke away from traditional construction work and became a performance, a jam session of improvisation and creativity. Due to limited predictability of the process a building contractor was not engaged to install Entropy. The four objects needed to be assembled 5m above ground. Each object is made from two separate laser-cut sheets of brass which are joined together. Due to small differences in the cut tolerances, material thickness and final pattern each of the eight brass modules behaved slightly differently under the forces of gravity. It was necessary to develop individual approaches for expanding and installing each of the unique pieces to overcome the inconsistency in the digital fabrication process – arguably continuing to design during the action of construction (figure 7). This part of the process was a collective manual process, which involved the participation of the designers and installers. In the case of Entropy it involved extensive improvisation, many obstacles and the creative avoidance of potential failure. At that stage the series of failure loops, the lost of digital correctness, the lack of miraculous seamlessness, the incapability of engineering process opened the opportunity of producing a real handcrafted object and enjoy a performative freedom during the installation.

4.3 The outcome

In discussion with the client and visitors to the opening, they perceived this piece of work as a unique and handcrafted one (figure 8). After the failure of coding and manufacturing unique pieces that came as a surprise to us. The logical reason was that last cycle of realization is what influenced the end result vastly. What was originally conceived through a digital design process and realized by digital fabrication was ultimately rendered, in the eyes of the client, as a crafted artefact. The set of complications and manual improvisations during the final cycle, the realization on-site dramatically changed its aesthetics. What Colletti derives as completely virtual property, the random complexity of parametrically generated surfaces (Colletti, 2007), is achieved by this installation in real material despite the obstacles in the digital part of the process and through the analogue/ tactile final process; arguably a glimpse of what might be conceived as post-digital poetics.

5. Discussion

This work-in-progress is part of an investigation of digitally sponsored design and implementation, exploring a technologically supported creative process, what Blythe and van Schaik would describe as 'where we are and where we want to be' (Blythe & van Schaik, 2013, p. 57).

We strip down and analyse a series of intuitive design steps, obstacles and technical errors and consider how they influence the design decisions and outcomes. The high expectations of seamless and user friendly digitally driven coding and fabrication processes have a considerable influence on the creative process and on initial design decisions. The unpredictable outcomes explained by failures in controlling the form digitally redefined the whole workflow and unleashed a more post-rational work approach. We moved from an engineered architectural digital approach, to a pre-architectural pre-programming one of form follows materiality. This process of reverting to pre-design, where neither documentation nor representation were available, was instrumental in the development of a hybrid design workflow. We believe that this represents a prevalent methodology or phenomena in the design and making industry for a transition from digital design to post-digital. It is what Dowton calls ‘architecture between making and doing ‘ (Mark Burry, Ostwald, Downton, & Mina, 2010, p. 108).

Another critical observation of ours is that high end teams using the full power and productivity of digital setup, often ignore or neglect the intuitive and random nature of the digital design process. The amount of work and expertise driving such projects is often obscured and creates a false culture of optimism regarding the primacy of digital technology. This prevents architects and designers from ‘leapfrogging areas of knowledge that it may not need or understand – or which do not conform to the pictures we require’ (Connah, 2001, p. 144). This work was largely inspired by the opportunity to test this optimism fostered in the world of digital design in the last two decades (Hump p.144).

> ‘Architecture can try to be even cleverer in its own blindness… In its discourse we can say everything and anything about architecture. Architecture would be on a roll, and we would be enjoying ourselves’ (Connah, 2001, p. 144).

The outcome of Entropy at a certain point became disconnected from the traditional, theoretical and the digital/engineered process and followed the only possible direction of improvisation and unintended or serendipitous making. This design research makes several contributions to the body of knowledge. First, by invoking Coyne and Snodgrass, it has framed design as a hermeneutic process

despite the result oriented digital culture. Through this lens, much of what is considered contemporary digital design, we categorise as digital fabrication of digital concepts. Second, through the design and installation of Entropy, and the observations and analysis of the processes observed we recognise that “correctness” is implicit in the materialisation and engineering of things. Third, “craft” remains an important part of the process, although designers also need to be crafting code. Perhaps we are seeing the re-emergence of the master builder, albeit with an expansive set of skills – both digital and tactile. We do not claim Entropy provides a prescription for digital design success; further research is required into understanding the consequence of digital design. However, Entropy provides valuable insights into two fundamental problems of contemporary digital design as discussed in the opening section. Entropy’s value was not attributed to its complex computational and digital fabrication processes, nor was it devalued as ‘robot porn’ and dismissed as folly. In this regard Entropy presents us with a dichotomy, the breakage and improvisation that occurred during its design and construction process can simultaneously be rendered as a failure of digital-design or a success of post-digital design. One where investment in computation and complexity are not direct metrics for value.

This project, the two artefacts and two videos presented at the RTD exhibition are part of a PhD with creative practice investigating hybrid post digital processes, digital poetics and design communication.

Figure 9. Entropy.

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