Technofactory versus Mini-Plants: Potentials for a decentralized sustainable furniture production

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Abstract: Custom-tailored mass production appears to be post-industrial and neo-craft in one. This ambiguity suggests that it can be approached from two different directions: from the side of the industry and from the side of the craftsman trade. Whereas there are numerous examples for the path from mass production to the mass customization, the development potentials of skilled trade businesses have barely been examined. Precedence for this is being set by the research project C-furniture. Its objective is the implementation of a strategy of mass customization through a network of CAD/ CAM-supported joinery workshops and a renewed competitiveness with regard to craftsmanship production. Their competitiveness could be further improved through art customization based on the new technologies.

1. Introduction

Let us first mention that the German furniture market today is almost entirely dominated by industrial businesses. Handcrafted furniture production for private customers gradually declined in scale and importance over the course of the 20th century. The joiner's trade was unable to compete with the furniture industry, which was based on economy of scale and low prices, although it was able to adjust somewhat by adopting industrial production methods and materials. This imbalance between industry and the craftsman trade could again be set into movement through digital information and communication technology, the availability of computer-supported tools and production processes as well as an increased demand for ergonomically custom-tailored and aesthetically individualized products. With CNC centers and laser cutters, the craftsman trade is able to utilize the same high-tech tools as industry. 10 to 20 percent of the joinery shops in Germany are already equipped with CNC machines. It appears entirely possible that small and medium-sized companies can re-conquer lost business fields in the private sector from industry. However, industrial companies and start-ups are adjusting to the changing conditions by offering customers "custom-tailored furniture." Leaving aside the technological parity, the paths of industry and trade to the "new center" seem to be quite different.

Based on the two-year long research and development project "C-MOEBEL" (C-FURNITURE) realized by the C-Lab of HfG Offenbach in cooperation with several corporate partners, we will present the results of the project, which have the goal of contributing to the strengthening of the position of skilled trade businesses in the competition with industrial suppliers. In addition, the opportunities and hindrances for the "handcrafted" path towards mass customization will be reflected upon. Four small and medium-sized joiner's shops were among the "C-MOEBEL" project partners, all providing special experience with CNC technology and all having cooperated since 1997 under the registered trademark Newcraft. The goal of these companies is to establish a second footing with high-quality CAD/CAM custom-tailored furniture at competitive prices in addition to their traditional business fields, such as executing interior design, manufacturing of staircases and windows. As Newcraft signifies with its name, the goal is a new form of craftwork with respect to the design of the products, the planning and production tools, the customer communication and the distribution channels. Instead of traditional high-priced customization, a competitive and productive digital crafts customization based on new technology is striven for.

2. Scenario of virtual production

The basis of the C-MOEBEL research project was a "Scenario of virtual production," which – connected with Piore / Sabel (1984) and Davidow / Malone (1992) – was developed at the C-Lab of HfG (Gros 1995). It reflects the structural change, promoted by digital technology, using the example of furniture production and comprises the entire process chain – from product development and customer communication to production and distribution. The theory that digital information, communication and production technologies benefit a regionalization of production was decisive for the development of the scenario. Davidow / Malone (1992) argued: "The virtual enterprise ... loathes distance. If it can find a friendly location close to its customers, it will prefer to settle there. This proximity promotes mutual understanding. You can meet

customers in person more frequently, get to know their needs and concerns, and develop your products precisely according to their wishes. In addition, the probability of something going wrong decreases the closer the product is to the customer." With respect to the high transportation and distribution costs of the furniture industry, a regionalization of this product segment seemed to be especially sensible and promising.

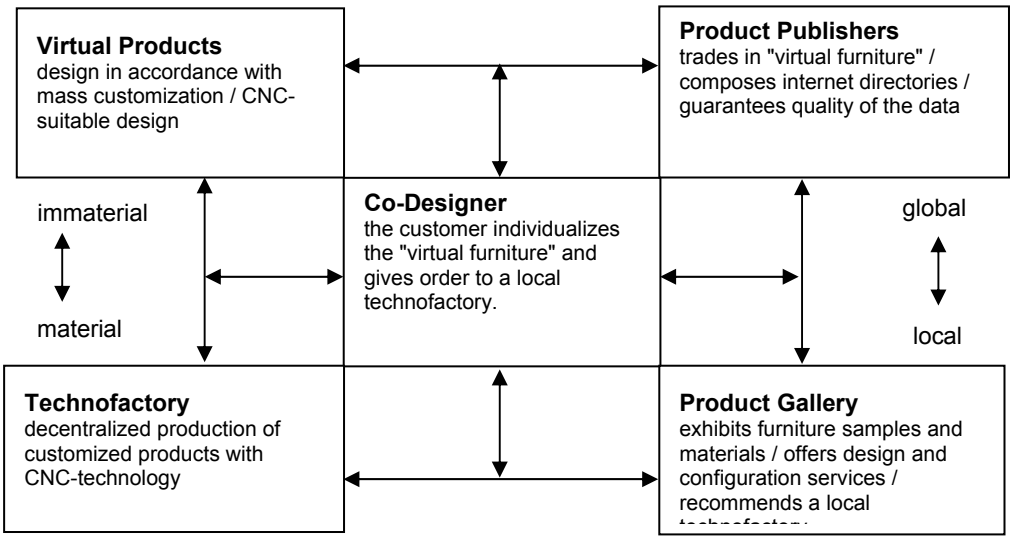

Fig.1: Scenario of virtual production

The scenario of virtual production (figure 1) presumed that the cards would be reshuffled and that new actors would take the stage in the typical interaction between designers, manufacturers, the trade and consumers that had emerged in the course of industrialization. Moreover, product design and development would have to be adjusted to the new conditions.

1. Virtual products: Given the fact that production technologies have a great impact on product design – at least in the field of furniture – computer numeric controlled technologies afford completely new CNC-suitable designs. Neither traditional trade design nor modern industrial design is suited to the new technologies and to mass customization. (Gros 1995, 2001) In order to achieve cost-efficient production, the furniture design has to conform to the requirements of digital technologies like CNC-milling and laser cutting. If this precondition becomes a fact, a "virtual product" – i.e., a ready-for-use dataset for machine control – can be "materialized" with computer-controlled tools, just as a text or graphic can be printed by a laser printer. Ideally, the furniture would be fully defined through its digital production program, thereby allowing it to be sent as a data file via the Internet and produced identically at any given location by a company that has CNC technology, but in countless versions with regard to size, material, color, etc., according to the wishes of individual customers. Since the transportation of data via the Internet is cheaper and faster than the transportation of material goods via the highway, this will lend an impetus to a regionalization of production.

2. Product publisher: At the same time, however, the data network and the fact that the development of "virtual products" neither pays in a regional market nor can it be realized by small manufacturers, should tend to lead to a globalization of the trade with

digital product design. This task could be fulfilled by the management of an "electronic directory" by a product publisher – similar to traditional pattern books – in order to mediate between the design offers of the designers, on the one hand, and the design demands of small and medium-sized producers, on the other.

3. Technofacture: Furthermore, it can be expected that digitized furniture production will develop beyond the traditional joiner's or locksmith trade. Since a wide variety of materials like wood, wood-based materials, acrylic, glass, metal, etc. can be processed with the digital tools, the neo-craft production of the future will organize itself in a cross-material and cross-craft way. This "technofacture" will be equipped with cutting-edge technology but will function following the old model of manufacturing in a decentralized and custom-tailored way.

4. Product gallery: Since the technofacture produces only upon receiving an order and on site, the former furniture trade becomes superfluous. A combination of an Internet presence and a local product gallery that presents patterns, material samples, etc. and consults with customers with respect to the configuration of their furniture seems more favorable. The product galleries, which require less exhibition space and lower margins than a traditional furniture store, can be operated within cities. However, they can also be affiliated with a technofacture and offer all of the advantages that make sales outside the workshop attractive.

5. Customer as co-designer: Given the increasing possibilities of co-designing the production process, the customer has already been described as a "prosumer" (Toffler 1980) or "co-producer" (Davidow / Malone 1992). In order to express the increasing influence of the customer on the design, which not only comprises the measurements, materials and colors but also the artistic manner of surface design, the term co-designer was coined.

In the end, the scenario of virtual production reflects the sustainability debate. The above-described technological and structural change is in step with ecological demands and the goals of sustained regional development. Decentralized production, service and marketing result in reduced importing and exporting of materials and an expansion of local economies (Bierter 1999). Additionally, customized, high-quality furniture and connected services will be of practical and aesthetical value for a longer period of time. The high quality of the materials and production, and the design, which aims at the possibility of expanding and repairing, enable greater durability. But the consideration of customer wishes and the integration of the future user as a co-designer also favor the appreciation of and identification with the product and encourage long-term use. Both factors – decentralized production and improved product qualities of crafted customization – will contribute to the preservation of the substance of the natural potentials.

3. C-Moebel – Research for Tomorrow’s Production

Referring to this vision of a neo-craft and decentralized production, essential components were simultaneously developed within the framework of the research project "C-Moebel" (C-furniture): the design team of the C-Lab of HfG developed a collection of "virtual furniture" compiled in a database (a so-called “electronic directory”). In the first step, the design team developed the construction principles and basic forms of the furniture. In the second step, the customizable attributes of the

furniture – size, material, color, finish and even CNC-engravings and intarsia – were defined. The optimization of the designs in terms of production technology was achieved in cooperation with the Newcraft joiner's association, which will be in charge of the custom-tailored production and distribution of the furniture collection in the future.

3.1 CNC-compatible furniture design

Following the premise that product design has to reflect the production technology, the furniture fully utilizes the new conditions and possibilities. Conforming to the current state of the art, the design is grounded on two construction principles and combinations of these principles: digital wood joints and a folding technique. Digital wood joints can be produced in a single pass of the piece of furniture via 3-axle CNC milling. As integrated joints, they become both constructive elements and design characteristics of the furniture form. (Figure 2)

Fig.2: CNC-milling and integrated joints (C2_System, Design: J. Gros)

Additionally, a so-called folding technique is employed in the furniture designs. It allows for the folding of coated panels into furniture bodies, similar to origami. The boards, which have a flexible, tear-proof coating, are milled in a V-shape via CNC and then folded; the coating serves as a connecting joint. (Figure 3+4)

What's decisive for both techniques is that the use of special furniture fittings and accessories becomes superfluous. The furniture is fully defined through its digital production program. The publication "C-Moebel, Digitale Machart und gestalterische Eigenart" (Steffen 2003) offers an overview of the entire C-Moebel collection and also presents CNC-compatible design and construction principles and exemplary CNC-produced furniture from approximately 50 designers and architects from Germany, France, Italy, Switzerland, UK, Israel and the United States.

Fig.3: Milling and folding of a chair (Cig-Cag_Chair, Design: J. Gros)

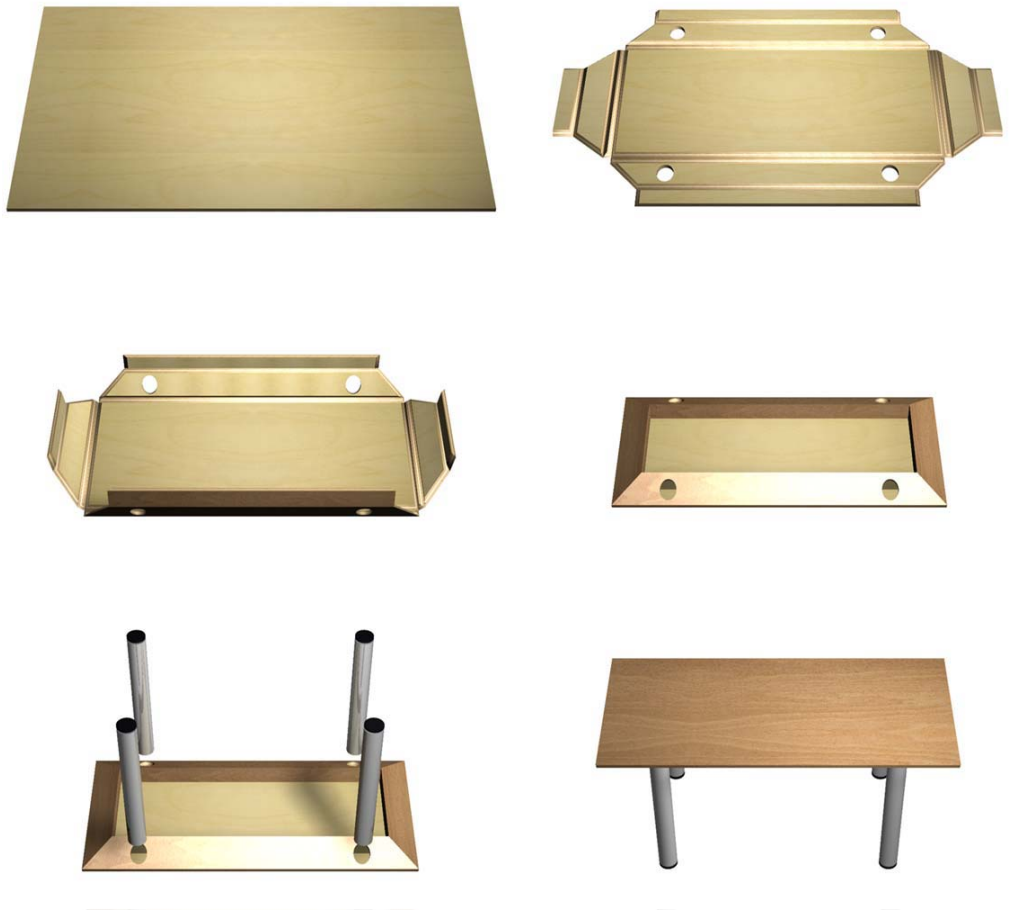

Fig.3: Milling and folding of a table (König Ludwig_Table, Design: J. Gros)

3.2 Product configuration via an Internet directory

The research project also investigated the development of an Internet-based, user-friendly product configuration tool that automatically transforms customer data into production data. After the conclusion of the research project, approximately 20 pieces of furniture will be available via the Internet directory. The furniture will be presented through pictures but also through virtual reality as VR objects. Customers can chose from the various furniture types just as they would in a traditional pattern book and – supported by the product configuration tool – can create a piece of furniture that meets with their individual needs in terms of function, size, shape, material and color. The versions are created via dialogue boxes and mouseclicks. The configuration tool automatically checks the plausibility of the design and calculates the price. The order can then be transferred online to Newcraft. Alternatively, a joinery located near the customer can be consulted and then commissioned with the production.

3.3 Digital crafts customization is only in its infancy

As the experience of various furniture suppliers has shown thus far, the Internet presence of the Newcraft furniture collection won't generate sufficient demand for launching a reasonable (small) serial production. Therefore, Newcraft plans additional marketing measures – for example, the establishment of showrooms associated with the workshops and distribution through design-oriented mail order catalogues. Altogether, the preconditions for initiating crafted, Custom-tailored production at competitive prices present themselves as being suitable, although a number of obstacles have to be overcome. For example, since the conclusion of the research project the joiner's shops provide the electronic directory; however, the key function of the product publisher described in the "Scenario of virtual production" has not yet been established. So far, there is no competent individual to run such a product publisher, someone who can take over the updating and care of the virtual furniture collection, decide about the addition of new products and product lines, maintain contact with designers, deal with design licenses, establish a national network of producers and, not least, familiarize potential clientele with this new, old way of buying furniture "from the joiner's shop around the corner."

4. Strengths and weaknesses – on both sides

Whether the industry or the trade approaches the goal of a custom-tailored furniture production based on digital technology – both are confronted with new tasks. For the industry, the transition to mass customization often means giving up the benefits of the efficiency of mass production. The cost of product development increases since the task is not only to design a standard product but also to pre-plan all of the possible options for individualization. Custom-tailored products also create greater complexity with regard to production. And instead of simply delivering the products to the showroom or warehouse, the manufacturers now have to contact their customers themselves. Customer Relationship Management (CRM) becomes a new priority and requires, among other things, the development and maintenance of web-based product configurations. The question of a centralized or decentralized production is answered in different ways by the industry: for example, Invido (Gros 2001, Kornacher/Piller 2003), who make custom-tailored box furniture for private customers, and Officeshop

(Kornacher/Wiedemann/Piller 2003), who specialize in office and public-use furniture, established a centralized production during the past years. The Italian furniture supplier of Op Top (Sulzer 1997, 1999) and the German kitchen supplier "Küche Direkt" (Kornmacher/Suwelack 2003) have pursued and are pursuing a decentralized production concept. The higher expenditure is countered by a few decisive advantages for industrial mass customizers: for example, they win orders from customers who they would ordinarily not reach with a standard program, and they can depend on the relatively certain purchase of the individually produced products by the customers.

4.1. The "crafts" way

The challenges that crafts businesses are confronted with in deciding on digital crafts customization are entirely different. They have the advantage of location; however, as "lonesome warriors" they barely have a chance to hold their own as digital crafts customizers. Networks of craftsmen and cooperations are much more promising. For them, the computer and Internet supported planning and production tools provide combined force with regard to product development, and the Internet directory promises to overcome the dearth of appropriate product designs for the new craft production. Product innovations and design services will thus become affordable for the craftsman trade. The businesses can fully shift their focus to production, marketing and customer services. Direct contact with the customer will generally be preserved but essentially supported and facilitated and, at times, entirely taken over by the product configurator. Distribution expenses remain unchanged and for some products may become irrelevant if customers pick them up themselves.

The availability of CNC-compatible virtual products opens up the potentials of digital technology for production. In addition, the production of (small) series enables the development of stable, standardized production processes and a pre-production of standardized product components independent from orders, which can later be either processed further in a custom-tailored way or be combined with individually produced modules. Altogether, the complexity of the production planning and controlling is reduced in comparison with the traditional made-to-order crafts production for which the product as well as the production process had to be newly conceived each time. (Piller 2000, 2003) However, the establishment of standardized processes may be considered "industrial" by many craftsmen, and they may find it difficult to reconcile it with their self-image. In this respect, the strategy of digital crafts customization requires a modified self-image in the trade businesses. The new way of thinking required for the production processes is also necessary for cost accounting. The calculation, of course, cannot be based on the traditional production of unique specimens. Even if the demand is low at the time of the market launch of a collection and only small numbers can be produced, the calculation should not be based on these numbers but should be oriented towards the aimed-at production numbers.

One of the biggest hurdles that small and medium-sized businesses will have to face is the generation of a sufficient number of orders. Under the premise of a re-regionalization of furniture production, the goal of *mass* customization, a custom-tailored *mass* production, seems barely achievable since there will not be masses of orders in the restricted trade zone of a given region and within a timeframe of one to two weeks for a specific product type. Still, the high-tech joinery needs – depending on the product – perhaps 5, 10 or 50 orders for a product type to make production rational, which will then be realized in custom-tailored versions. Despite "virtual products" and short machine setup times, the production of only one or two examples of a type is

rarely worthwhile. The requirement of minimum quantities and the appropriate orders received therefore point to the necessity of marketing and branding as has been customary in industrial production for a long time. Whereas small businesses working for an unambiguous market used to be able to rely on the "good name" of the master to become a household name, furniture production for private customers today demands the formation of brands. (Gros 2002) This especially applies to member firms of cooperations like Newcraft, who present themselves on the market together. To the customer, catchy brand names – especially if they appear on the product itself (figure 5) – increase the recognition of a supplier; they additionally signalize specific product qualities and a corporate history and philosophy that points beyond the product. Frank T. Piller emphasizes: "Mass customization requires branding... Classic branded companies therefore ... have a clear advantage when it comes to the introduction of a mass customization solution." (Piller 2001) Whereas well-known and proven serial products in a sense serve large brand producers as reference points for the production of "virtual" products commissioned by individual customers, smaller, less known suppliers have a much more difficult time convincing customers of their own efficiency.

Fig.5: Laser cut inlay as joiners brand sign

One important challenge for trade businesses and cooperations that pursue digital crafts customization will hence be the sales approach and establishment of new "post-industrial" distribution channels. Complementing the workshop with a showroom is only one element. It would be especially attractive if the showroom – analogous to the "glass factory" of VW in Dresden – would be combined with a "glass workshop.” Such shopping experiences are in demand today – as the example of VW proves and sociologists, business managers and marketing experts unanimously state. (Pine 2000) But this strategy alone will not pave the way to the market simply because the businesses are usually settled in industrial areas or on the outskirts of cities and towns. Therefore, product galleries in the inner-city shopping zones as were conceived in C-Lab's "Scenario of virtual production" might attract more attention. The establishment of a showroom or a product gallery may imply a greater effort for individual businesses or networks compared with the distribution through the furniture trade; however, this greater effort is countered by higher profits due to the elimination of the markups of up to 300 percent that furniture stores usually add. The manufacturers should have plenty of elbowroom for profitable gains *and* competitive prices when selling directly ex-workshop and processing the orders through the product gallery. For example, a local joiner's shop had positive experiences with the establishment of their own sales room in a central location; one year ago, they opened the "Lebensraum" (living space) in Münster's inner city (www.lebensraum-wohnkonzepte.de).

5. What is the difference between joiner's shop, technofacture and mini-plant?

In the end, the question with regard to how the medium-sized, high-tech joiner's shop and the mini-plant mentioned by Reichwald, Piller, Jaeger and Zanner (2003) differ, and which player has the better prospect of holding his own as a furniture customizer in the future. One distinctive characteristic is the fact that local, well-established joiner's shops that want to become digital crafts customizers most likely will retain their existing business. Whether and how they will succeed in simultaneously managing these divergent fields – with respect to organization and to their self-image – in *one* business remains to be seen. (Steffen 2003) In contrast to this, the decentralized mini- plant will exclusively focus on the custom-tailored production of its collection, and on direct customer contact and services throughout the product life cycle. The mini-plant will therefore be *smaller* than the usual trade business as the "smallest possible production unit." Reichwald et al (2003) mention the mass customizer "Küche Direkt" as an example; their decentralized production facilities "consist of a highly automated manufacturing system, the process control software, a configuration and sales unit and the construction software translating a customer's order into a parametrical product design. The whole factory is operated by just two workmen and one sales assistance." Such small units function well since they are affiliated as franchisers with a company that offers services like product development, training or the providing of prefabricated components. The business model and identity of the mini-plants will be clearly oriented towards the model of industrial production.

The high-tech joiner's shop will also differ from the mini-plant by being rooted in its tradition and self-image in a craftsman trade, whereas the mini-plant understands itself as a cross-trade business that is open-minded towards the most diverse range of materials and production technologies. Product designs that combine various materials – as is customary in design – thus comply with the possibilities of the mini-plant rather than with those of the joiner's shop. Of course, the most obvious solution would be the establishment of cross-trade cooperations and networks or the technofacture that unites various trades beneath one roof. Both would amount to the model of a cross-trade technofacture as it was developed in the "Scenario of virtual production." With respect to the technical equipment and the processing spectrum, the cross-trade technofacture and mini-plant would be equivalent. It remains to be seen whether "craft" technofactures or "industrial" mini-plants will determine the re-regionalized furniture production in the future. The issue regarding whether the trade will be able to seize the opportunity for itself will probably depend on "soft factors" such as the internal structure of craft networks and their ability to function. Finally, it is conceivable that the mini-plant and technofacture will share the market of individual and decentralized production similar to the way that McDonald's and local restaurants do.

5.1 Art customization – a special trump of the trade

The confrontation between the "craft" and "industrial" path towards mass customization gains a new dimension through the possibility of individualizing and personalizing the surface – in the end through the re-ornamentation of the products. This development towards art customization is especially favored by the new technologies like laser engraving; it increases the inherent value and requires additional consulting – at best in a personal conversation on site. Here, the manufacturer of furniture is requested not only as a "craftsman" with CNC competence but also as an "arts and craftsman" with CNC competence.

With this special interest for the artistic design of C-furniture, the feasibility study "Art Customization" (Gros et al 2001) started at the C-Lab shall now be continued in a project under the responsibility of the Hamburg chamber of commerce. Here, like in hardly any other German city, there is the possibility of including successful arts and crafts people into the development of CNC-compatible furniture. Such concise approaches to a NewArts and Crafts movement or the vision of art customization are, of course, in their very beginnings. But the technological conditions for a renaissance of the applied arts in the context of mass customization seem to have long been available. And the renewed interest of the artists in the issues of the applied arts is immense. One example is the exhibition "Ornament oder die neue Lust am Verbrechen in der zeitgenössischen Kunst" (Ornament or the new lust for crime in contemporary art) in Munich's "Luitpoldblock". There, the motto is: “Today ornamentation is no longer a crime. Adolf Loos once condemned ornamentation as feminine, instinctual, primitive and a hindrance to cultural development. He was highly influential. In the 20th century, ornamentation was frowned upon. In contemporary art and theory, ornamentation is experiencing a renaissance. The work of an artist not only reflects internal questions about art but also various aspects of the subject of ornamentation in the contemporary cultural context as such. They move between coordinates like ornamentation, decoration and pattern and evoke core questions of artistic action.” (www.luitpoldblock.de) The next step to take from general questions about ornamentation to the development of a specific ornamentation and its realization with the new technologies is described in the book "Icon Language.com" (Gros 2003). It elaborates how pictographic or iconographic ornamentation could look within the context of mass customization – comparable to hieroglyph as ornamentation. The outlook for these tendencies of art customization, however, should only serve to indicate that we can at least imagine design developments that favor the path of the crafts towards mass customization.

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