# CHALLENGING AND EXPANDING THE EVOLUTION OF FORM-MODEL

**IN:** PROCEEDINGS FOR THE NORDCODE CONNECTING FIELDS CONFERENCE
OSLO, NORWAY, MAY 10–12, 2006
URL: HTTP://NORDCODE.TKK.FI/OSLOPAPERS/CHERYL_AKNER_KOLER.PDF (ACCESSED MAY 2007)
REVISED VERSION JUNE 2007

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**KEYWORDS:** FORM, DESIGN, AESTHETICS, ECOLOGY, 3-D SCANNING, PRACTICE-BASED

## Abstract

Two studies in transparency and material breakdown are presented that expand the Evolution of Form (EoF)-model along two axes. The transparency study using 3-D scanning technology that transform the *twisted curvature* sculpture into a transparent point cloud volume. A new stage, *Transparency,* is introduced expanding the EoF-model along the horizontal axis. The model is further expanded along the vertical axis to include material breakdown that introduces a natural process of dehydration as a means to distort and deform. Color, texture, density, smell etc. are introduced as new properties that are included in the process of deformation. Issues of ecology and string theory play a role in the development of these two studies, as well as combining low and high technology.

The revised model aims to integrate relevant contemporary issues in the EoF-model. The concluding remarks present a skeptical attitude to the revised EoF-model, especially in reference to the material breakdown study. Comparing the original model with the revised model does, however, provide a way to highlight both strengths and limitations of the original model.

## Introduction

The foundation for aesthetic reasoning in the field of industrial design was established during the first part of the Industrial Revolution. The core of this aesthetic reasoning for shaping form was based on four major factors. The first is perceptual awareness of geometric structures and spatial abstraction (Greet 2002, Wick 2000). The second is traditional craftsmanship through the drawing and sculpting of figures and nature studies (Wick 2000, 382 [1982]). The third is learning about scientific methods to develop the field of design (Cross 2002), and the fourth is the possibilities and limitations that technology and the manufacturing process offered (Chernikhov 1989). In this paper I aim to show that these four factors continue to expand and challenge the aesthetic paradigm for industrial design.

The article builds on both previous work I have done in form theory and practice developed within an industrial design educational framework. The issues here deal specifically with further development of a model that reciprocally merges geometric properties with organic properties, referred to as *Evolution of Form* (EoF)-model. For a background of the EoF model, I refer the reader to the article “Expanding the Boundaries of Form Theory”

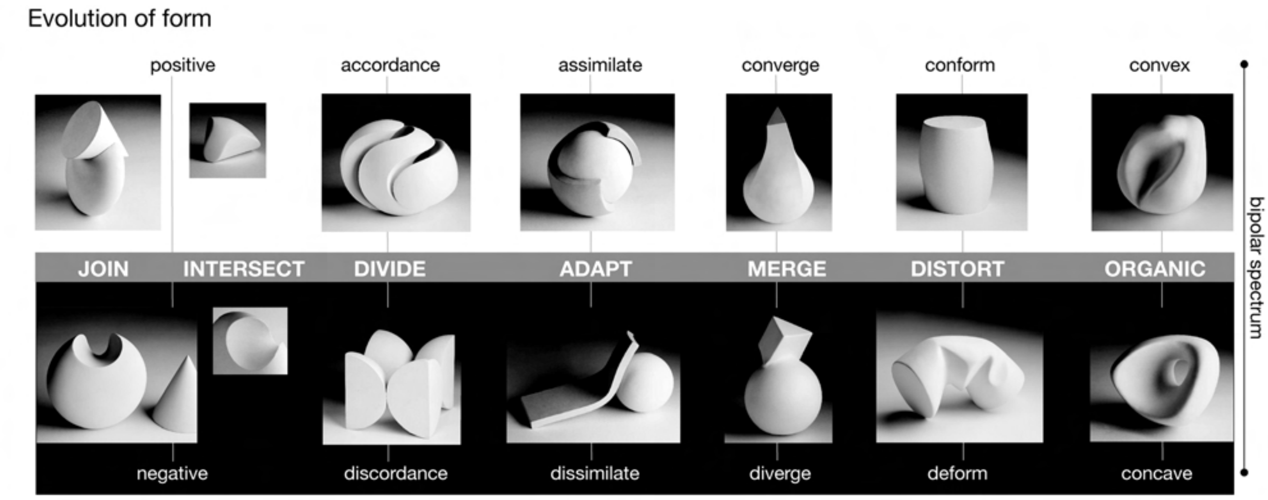


**Fig.1** The geo-organic Evolution of Form-model

The EoF-model and the abstract principles and analytical approach on which it is based are presented in more detail in the textbook *Three-Dimensional Visual Analysis* (Akner-Koler 1994). I also refer the reader to the work of the founders of this modernistic abstract reasoning, Rowena Reed and Alexander Kostellow (Greet 2002). The present paper involves two paths that expand and challenge the model. Challenging the model involves a paradigm shift introducing non-geometric and complex ways of working with form. Expanding the model means that there are direct links to the different sequential stages and/ or the bipolar spectrum.
Photo: Åke Sandström.

(Akner-Koler 2006). The article explains a *10-step Concept-Translation-Form*-method resulting in the development of the geo-organic Evolution of Form-model as shown in figure 1. Briefly, this model consists of two axes. The horizontal axis presents a sequence of seven stages that are geometrically derived forms gradually taking on organic qualities of convexities and concavities. The seven stages are: *join, intersect, divide, adapt, merge, distort* and *organic*. The second axis expands the model in a vertical dimension to include a *bipolar spectrum* (±) at all stages. This vertical dimension opens up a spectrum between congruent and incongruent properties in relation to features of the original geometric form. The bipolar concepts are: *+accordance – discordance, +assimilate – dissimilate, +converge – diverge, +conform – deform, +convexity – concavity*.

The negative pole in the bipolar spectrum introduces a way to consider the aesthetic properties dealing with *breakdown,* which questions the overriding principle of beauty usually associated with the organizing capacity of geometry. The negative pole also supports the sculptural qualities concerned with *void/ concavity.*

**Model development**

Two studies will be presented here: Complex curvatures and Ecology/ Material breakdown. The specific questions these two projects deal with are, respectively:

1) How can we gain new aesthetic awareness by studying twisted cyclical curvatures using advancements in 3-D digital scanning technology?
2) How can environmental questions inspire aesthetic reasoning? Methods, results and discussion are presented separately for each study. Both projects challenge and expand the EoF-model in figure 1.

**Study 1: Complex curvatures - transparency**

The Complex curvatures study emerged during an art-science collaborative project concerning the theme *Infinity*. Over a nine-month period, three physicists - Lars Bergström, Narendra Yamdagni, and P.O. Hulth - and one artist, Cheryl Akner-Koler, met regularly to explore aspects of the theme Infinity and to prepare the content of an exhibition and program for an art/ science festival at Kulturhuset in Stockholm in 2002 (Akner-Koler and Bergström 2005).

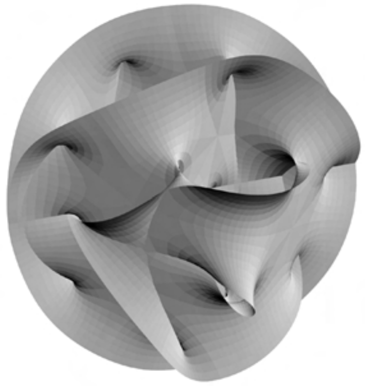

**Fig. 2** The Calabi-Yau manifold-model by Lars Bergström.

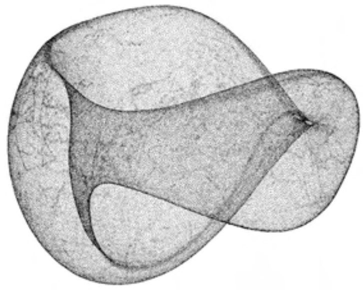

**Fig. 3** Point-cloud volume by Akner-Koler.

**Fig. 4** The *Twisted curvature*-sculpture surrounded by point-cloud images. Photo: Åke Sandström.

*Methods*

Early in the project, Bergström and Akner-Koler recognized a common interest in *non-trivial curvatures* that twist and curve within an infinite cyclical path having no beginning or end, as well as no separation between the inside and outside. Bergström's background in theoretical physics and his interest in string theory inspired him to further develop his conceptual and perceptual awareness of the digital model of a Calabi-Yau manifold, as shown in figure 2. I created a compound twisted sculpture that explored variations of density, width, and a shift of accents based on the construction of a Möbius´ strip, as shown in figure 3. The convexities and concavities of this sculpture were developed through sculpting aesthetic principles rooted in the work of the Russian sculptor Alexander Archipenko, and the American sculptor, designer and educator, Rowena Reed (Greet 2002). The sketching process was done using Kolb (URL) ID clay. The final sculpture, *Twisted curvature (figure 6)*, was cast in aluminum through a lost-wax method and then scanned by a 3-D digital scanner into a point cloud volume.

The article *Complex curvatures in form theory and string theory,* published in 2005, gives a detailed account of your collaboration, results and the exhibition (Akner-Koler and Bergström 2005).

*Results*

The results of this project came about through a combination of low-technology, sculptural craftsmanship with clay and high-technology with 3-D digital scanning. The translation of the physical sculpture through the 3-D scanner into a virtual point-cloud volume introduced properties of transparency. Sixteen point-cloud 2.5-D images were selected, printed and mounted on three curved, white, translucent acrylic surfaces that surrounded the sculpture in the exhibition at Kulturhuset (see figure 4).

We explored conceptual advantages of transparency inspired by the point cloud images. Bergström´s work with transparency created a new interpretations of the Calabi-Yau manifold that better represented the ideas of multi curvatures in string theory.

*Discussion*

The virtual point cloud volume marks a further move away from both the law-bound physical structure of geometry and stable objects in space that the first 6 stages of the EoF model build on. Point cloud volumes introduce amorphous characteristics with a vague spatial position, pushing the limits of the concrete expression of form exposing phenomena of density, overlap and multi-dimensions. This study also challenged our understanding of 2-D images of 3-D forms. Point cloud volumes expressed from one fixed viewpoint show the back and front of the volume in one view which expresses a 2.5-D image that compactifies dimensions into one frame. since the point cloud complex curvatures move through virtual space there is no clear sense of depth. The surface therefore can be easily transposed.

An unexpected result of this scanning experiment was that more than half of the 2.5-D point cloud images were not easily recognized as originating from the same sculpture. Although I know this form from all angles and from all stages of development, I was not able to locate the vantage point from which each image was taken. This experience posed questions as to our ability to grasp complex, transparent forms. Although we are able to

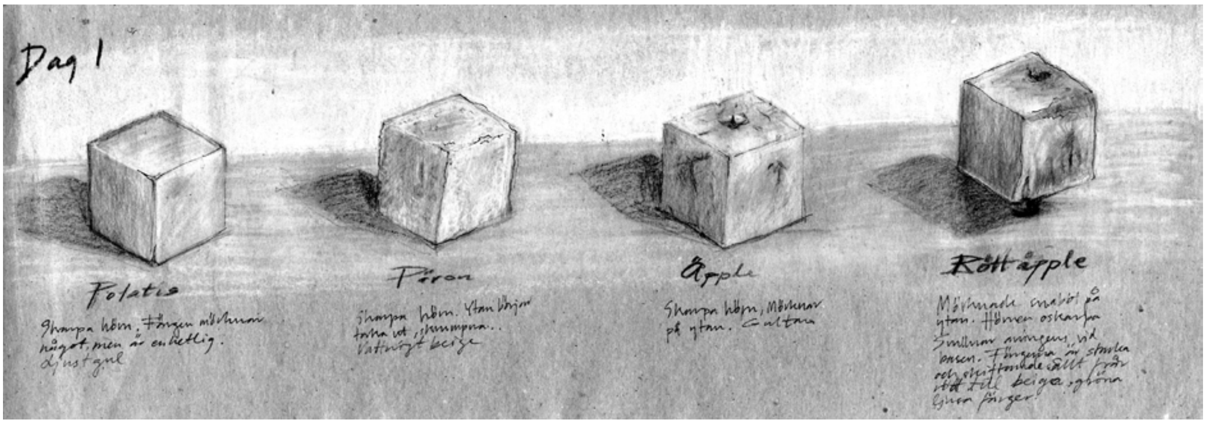


**Fig. 5** Student assignment of four different organic material (potato, pear, apple, red apple) of the first day of dehydration.

grasp a coherent and holistic 3-D image fusing together all different views of a solid form, it is much more difficult to grasp the superimposed, transparent point cloud images that show the back and front through the same view (ie. 2.5-D).

This combination of hand craftsmanship and high technology is a very central issue in merging embodied aesthetic experience with the visual abstractions of the digital world. The industrial design process is becoming increasingly dependent on digital images. We need to keep track of wireframe forms and polygonal surfaces that are complicated. An important question is: are we able to support aesthetic reactions and reasoning through these primarily visual media? Malcolm McCullough's (1996, 48–9) practical and theoretical work in digital craftsmanship brings up this issue. He both praises the hands and haptic experience and at the same time predicts the decline of physical objects as we offer more and more virtual solutions for solving problems. McCullough presents the situation of the "dematerialized artifact" and the changes in professions and technology that will bring new forms of visual knowledge in the virtual and real worlds. The point-cloud images presented here are a product of virtual technology that literally dematerialized the physical, solid sculpture by merging material points with spatial dimensions. At the same time, this virtual technology can "rematerialize" the complex curvatures of the sculpture through 3-D or 2-D printer technology. Following the development of a physical form as it is transformed into new imagery is one of the areas of development that form theory will need to include.

### Study 2: Ecology/ Material breakdown

This study involved dehydration of organic materials, inspired by an ecological theme at Konstfack in 1995–1996 (Svensson and Mi6 group 1996). The theme involved the entire school in finding ways to integrate ecological reasoning in the educational curriculum. Since ecology focuses on life cycle processes and decomposition of materials, I chose to problematize the aesthetical traditions of industrial design (which I teach in the first year) and developed a course on Ecology/ Material breakdown.

*Method*

A pedagogically framed study was developed at Dept. of Industrial Design (ID) at Konstfack for second-year ID-students. The study was ran parallel with lectures and seminars on the theme ecology that were arranged by the M6 group for the entire school.

We began by selecting organic materials, such as zucchini, pumpkin, potato, ginger, red beet and pear, and cutting the material into cubes of similar size. The cubes were left to dehydrate over three summer months. The students were asked to record the changes in a journal with drawings, photos, and descriptive text that discerned color, texture, form, smell, density etc. (figure 5)

*Results*

After the summer vacation, the organic cubes and student journals were compared. We discussed the experience of observing a gradual transformation of form and substance over time in relation to prior form studies in clay. A list of aesthetic concepts were recorded, such as crack, collapse, transparent, rough, slimy, etc.


**Fig. 6a–c** Three dehydrated organic cubes:
**a** potato (Photo: Olof Glemme)
**b** ginger root (Photo: Olof Glemme)
**c** pear (Photo: Åke Sandström)

The three photos of organic cubes  the figures 6a–c show the final stages of a potato-cube, ginger-root-cube and a pear-cube.

Figure 6a shows a potato-cube in the last stage of its dehydration process. The cube rested on a porcelain plate during dehydration (not shown in photo), which retained moisture at the base where the potato was in contact with the plate. This uneven rate of dehydration between the top and bottom of the potato cube caused a deep concavity at the top in comparison to the slightly raised concavity at the base. It is interesting to note that the distorted edges and corners of the cube are still sharp.

Figure 6b shows a ginger root-cube mounted on a wooden dowel during the drying phase, allowing the air to circulate around the whole cube. The twisted concavities are all very different on each surface in comparison to the potato cube. Some deep concavities emerged by adjoining surfaces twisting around each other, whereas others have more shallow concavities that move from slightly concave surfaces to convex. The ginger cube is strongly influenced by the way the long fibers run through the root.

Figure 6c shows a pear-cube that was transformed into a glowing translucent material with subtle color variations. The pear cube was dried on the tip of a toothpick, creating even conditions for dehydration. The concavities on four sides show collapsed and sunken surfaces that are also partly controlled by the edges of the cube. The two remaining parallel surfaces show a cracked and distorted star-shaped void with sharp negative points. All three organic cubes in figure 6 exhibited sharp edges and corners that were retained throughout the entire dehydration process. The concavities and surface deformation were controlled by the six separate surfaces of the cube.

Through discussions with students, the following conditions were highlighted:

- Context-dependency
- Temporal process
- Autopoiesis (ie. not controlled by the designer)
- Partial control by geometric structure
- Perceptual experience of the interrelationship between color, texture, smell, density, shape, etc.
- Complex features can not be separated from the properties of the material.

*Discussion*

The ecology/ material breakdown study explored the amorphic charcteristics of organic material. Using the structural features of a geometric cube to discern change and behavior of dehydration supported a comparative study, both as the cube changed over time and between the different materials. Material transformation controlled by geometry has previously been explored by artists such as Lucio Fontana in his “Ceramica spaziale” 1949 and Jean Dubuffet in his work with “Art informel”, as shown in his “La vie interne du mineral” 1959 (Bois and Krauss 1999), and recently in a large-scale object, “Bitumenkub” 1998 by Mikael Lundberg (Valjakka 2001). According to Dubuffet, this interest in material breakdown and texture was to oppose methods of compositional abstraction and to expose the formless nature of substance. These artists used unstable material transformation because they offer  means for expressing time, process and entropy that go beyond the concrete form itself.

The present study introduced an aesthetic approach which challenged traditional industrial design aesthetics that emphasizes positive gradual curves, tensional surfaces and highly polished shapes. By setting up explorative studies of non-traditional materials that change over time, we were able to problematize aesthetics by asking such question as: i) How do highly polished products defy aging or wear and tear? ii) How can spontaneous organic processes be introduced into product development? iii) Can ecological concepts, such as the cyclical processes of buildup and breakdown, inspire a different approach to aesthetic reasoning in product development and the field of aesthetics?

*Educational relevance:* The educational relevance of this ecology/ material breakdown study lies in exploring alternative ways of reasoning that can bring cyclical and process-based thinking into the design process at any level. Studying the dehydration of a pear may seem trivial, because it is part of our mundane everyday world. Yet, it is precisely this everyday world that can help us improve our traditional aesthetic reasoning in design. Tor Nørretrander (2003) points out that artists are able to "study the world itself", such as the flow of water or chaos in the kitchen, while science has a long tradition of ignoring the everyday world. He sees the artist's process-based working strategies as very valuable to the sciences, because they offer ways to go beyond the general laws of nature. I argue that design also needs to reclaim its roots with the arts and an awareness of natural processes. This ecological breakdown study supports a way to renew aesthetic reasoning so that both the logic of geometry and the unpredictable changes of the real complex world are included in our aesthetic consciousness. The pear-cube embodies the merge of these two worlds.

A majority of our ID students were unclear about the purpose of this study, because it did not seem to have direct relevance for designing products. To stimulate a stronger connection to product development, the students were assigned a project that linked these aesthetic ecological studies to product development. Two examples of the products developed by the students were: a) a computer mouse pad that was designed to show traces of the movements of the mouse and b) a bottle cap that glowed in different hues reflecting the age of the fluids within. An ad-hoc exhibition at the Future Museum in Borlänge, Sweden 1997, was arranged in connection with an exhibition Kjartan Slettemark and I had together called *Omvandla – Förvandla* (Metamorphose/ Transformation) (Degerman 1997). Both the material breakdown studies where exhibited as well as the suggested products. The material breakdown study has been given to students in our bachelor's and master's courses at the Dept. of Industrial Design at Konstfack in different ways over the years. Its main purpose has been to remind ID students of the vast aesthetic experiences that ecology and material breakdown include. It also stimulates a constructive and critical attitude to the classic geometrically derived form theory and practice I teach at Konstfack.
Two workshops were later arranged based on this theme ecology/ material breakdown: one in 1999 for the No Picnic design group and the other for a laboration in material transformation in a *Cross-disciplinary studies of Complexity and Transformation* 2003–2005 (Akner-Koler 2005) (URL).

## Concluding discussion

*Provisional revised Evolution of Form-model*
The two studies above challenged and expanded the *EoF*-model as shown in figure 7 and represent an important conceptual phase in development of the model. The studies were designed to challenge the controlling power of geometry and to move beyond solid form into complex curvatures and topological points in space. My point here is that some of the traditional methods of geometric abstraction and sculptural craftsmanship can be interwoven with new areas of exploration in the real world as well as in the virtual world. Because the original EoF-model merged geometry and organic principles of growth, it was not a rigid model to begin with.

The EoF-model was revised along both the horizontal and vertical axes through the phenomena transparency and material breakdown as shown in figure 7.

- *Transparency* expands the EoF-model next to the last stage "organic" along the horizontal axis. The concept transparency is suggested as an 8$^{th}$ stage to introduce a possible continuation of forms and concepts that go beyond solid volumes. In figure 7, a transparent point cloud volume has been derived from the concavity volume at the organic stage, thereby making up a transparency stage.

- *Material breakdown* expands the EoF-model along both the horizontal and the vertical axes to introduce more complex ways of organic deformation. First horizontally by stretching the axis between *distort* and *organic* (figure 7a), and second vertically at the negative pole *deform* of the bipolar spectrum, which shows a dehydrated organic cube as a means for deformation (figure 7d).

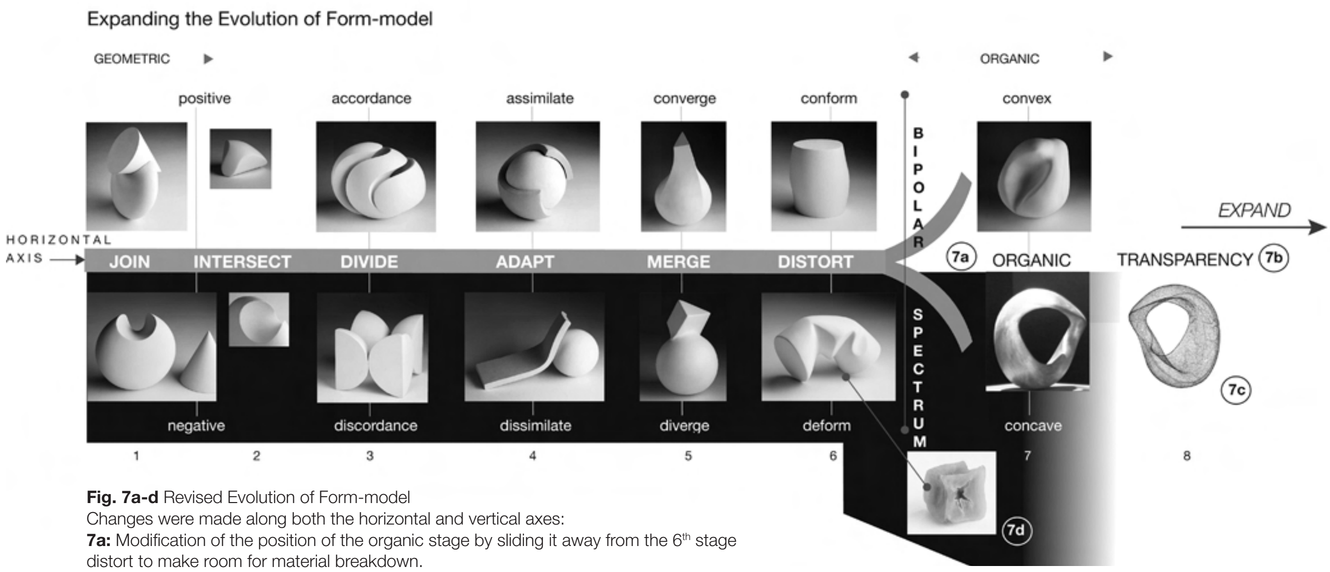


**Fig. 7a-d** Revised Evolution of Form-model
Changes were made along both the horizontal and vertical axes:
**7a:** Modification of the position of the organic stage by sliding it away from the 6th stage distort to make room for material breakdown.
**7b:** Adding the 8th stage transparency along the horizontal axis.
**7c:** Linking the concavity volume to the transparency stage.
**7d:** Vertical expansion of the bipolar spectrum at the distort stage, through deform at the negative pole.
Photo: Åke Sandström.

*Strength*: The strength of the revised model in figure 7 is to show ways to connect the aesthetic reasoning of the EoF-model that is strongly influenced by values from the early part of the industrial revolution with concepts (eg. ecology) and technology (eg. 3-D scanning) that are highly relevant today.

*Weakness*: The weakness of the revised EoF-model is that it becomes fuzzy when it moves into new modes of aesthetic abstractions. I am especially skeptical of the way the material breakdown study expands the model, since it introduces color, texture, smell etc., which the model can not properly deal with.

## Conclusions

The revised EoF-model exposes new areas of aesthetic abstraction and generates new ways to understand the principles and norms that build up the previous model. I feel that the revised model presented in figure 7 will not survive or replace the old model in figure 1, because of its inconsistencies. However, it is relevant to use the model in an educational context to test the limits of model development. The two studies, transparency and material breakdown, have merits of their own, aside from how they relate to the EoF-model.


## Acknowledgments

Thanks to Leif Thies from the Mi6 group who encouraged me to introduce an ecological awareness into aesthetics. Kjartan Slettemark helped me take on the challenge of aesthetic breakdown. I would also like to thank Lars Bergström for his open-minded and curiosity as we worked through the theoretical and practical advantages of transparency. Thanks also to the Industrial Design students at Konstfack, who allowed me to explore aesthetic questions that pushed the limits of traditional industrial design aesthetics.

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