AN EXPRESSION OF STATES
AND RELATIONS WHICH IS
INFLECTED, WHICH EVOLVES
A PROCESS SHAPED BY DIFFERENT
TYPES OF INFORMATION BEFORE,
DURING AND AFTER A BUILDING IS
MATERIALIZED

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PHILOSOPHIES OF DESIGN

THE CASE OF MODELING SOFTWARE

MANUEL DE LANDA

Manuel de Landa has lived in Manhattan since 1975, although he was born in Mexico City. He began as an independent filmmaker, but he’s mainly known for his books and essays about non-linear dynamics, theories of organization, intelligence and artificial life. He’s the author of 'War in the Age of Intelligent Machines' and 'One Thousand Years of Nonlinear History'. Although he doesn’t write about design, he works, paradoxically, as a designer doing 3D modeling by computer.

Further reading, see Manuel de Landa, “Deleuze and the Open-ended Becoming of the World”
www.diss.sense.uni-konstanz.de/virtualitaet/delanda.htm,
www.brown.edu/Departments/Watson_Institute/programs/gs/VirtualY2K/delanda.html
The widespread use of steel for so many purposes in the modern world is only partly due to technical causes. Steel, especially mild steel, might euphemistically be described as a material that facilitates the dilution of skills... Manufacturing processes can be broken down into many separate stages, each requiring a minimum of skill or intelligence. At a higher mental level, the design process becomes a good deal easier and more foolproof by the use of a ductile, isotropic, and practically uniform material with which there is already a great deal of accumulated experience. The design of many components, such as gear wheels, can be reduced to a routine that can be looked up in handbooks. One consequence has been that managers and accountants, rather than engineers, have become the dominant personalities in large organizations. Creative thinking is directed into rather narrow channels. Steel is, archetypically, the material of big business — of large factories, railroads and so on. James E. Gordon.

In this essay I would like to contrast two different philosophies of design, or what amounts to the same thing, two different theories of the *genesis of form*. In one philosophy one thinks of form or design as primarily conceptual or cerebral, something to be generated as a pure thought in isolation from the messy world of matter and energy. Once conceived, a design can be given physical form by simply imposing it on a material substratum, which is taken to be homogenous, obedient and receptive to the wishes of the designer. Steel, as the opening quote of this essay claims, is one such docile material, with predictable qualities and standard behavior. Although such a philosophy may seem natural to some designers, there is the danger that utilizing materials with routine behavior may end up affecting the design process itself, reducing it, at least in part, to yet another routine. The opposite stance would be represented by a philosophy of design in which materials are not inert receptacles for a cerebral form imposed from the outside, but active participants in the genesis of form. This implies the existence of heterogeneous materials, with variable properties and idiosyncrasies which the designer must respect and make an integral part of a design process which, it follows, cannot be routinized. I will illustrate these two opposite attitudes towards matter and form with examples from real materials first, and then move on to examples from virtual materials, that is, the "matter" inside computer simulations which is the basis of Computer Assisted Design (CAD).

The author of our opening quote, James Gordon, was one of the pioneers of the science of materials, a new field of science born in the 1950's from the conjunction of many separate areas: metallurgy, polymer science, glass and ceramics engineering, solid state physics and other minor fields. Thus, Materials Science and Engineering, as the field has come to be called, was from its inception inherently interdisciplinary. Gordon argues that, despite the importance in this century of new materials for economic and military purposes, none of those fields ever enjoyed a great deal of prestige, certainly nothing like the prestige attached to relativity or quantum physics. The reason for this humble status is directly related to the two philosophies of design I will be discussing. Real material behavior is complex, demanding an interdisciplinary approach, but science traditionally has looked down on such collaborative efforts. Hence, the complex behavior of materials has been typically neglected and reduced to simple, routine properties. The physics developed by Newton stripped materials of all their complexity and reduced them to "mass", while the chemistry which developed a century and a half later, dealt only with the simplest chemical properties and interactions.

On the other hand, craftsmen (blacksmiths, glassmakers, shipbuilders) always had to take the complexity of matter into account because before the advent of homogenized materials like steel, the materials available were always heterogeneous. A blacksmith, for example, would get his iron from one mine one week, from another distant one the following week, from a meteorite later on, each time dealing with different impurities and mixtures that demanded creativity and did not allow the process of creation of new forms to be reduced to routine. But precisely because the knowledge of complex material behavior was in the hands of craftsmen (and later on, of architects and engineers) there was a general disregard for it. Western societies, all the way back to their ancient Greek origins, have traditionally despised manual knowledge. Blacksmiths in Greece, for instance, were typically slaves or ex-slaves, and were regarded with suspicion by Greek citizens [even those who enjoyed metallic designs for ornament or weaponry] for spending their days surrounded by fire and dealing with metals, and more importantly, for not coming to the Agora to talk and discuss issues of citizenship and other high-minded subjects.

The blacksmith had plenty of knowledge, but it was *linguistically unarticulated knowledge*, know-how embodied in his hands, not the kind of knowledge that can be easily verbalized and made into con-
versation or put into books. Know-how, as opposed to linguistic or mathematical knowledge, has never enjoyed any prestige and has been largely ignored by philosophers as a worthy subject of study.

Today, thanks to Artificial Intelligence, this situation may change: we know now that getting machines to learn verbal knowledge (or any kind of formal knowledge such as that involved in playing chess) is a great deal easier than creating a mechanical hand that can design and create metallic objects. In other words, the type of knowledge that we always thought was the most characteristic of human rationality, and hence, what made us different from animals and machines is, in fact, the easier to mechanize. And the minor, less prestigious skills which we have always neglected to study, are the hardest to transmit to a machine, hence, the least mechanical.

Yet, Artificial Intelligence is rather new and has hardly begun to alter a contemptuous attitude towards manual skill and complex materiality which is rather ancient. Moreover, this attitude has been formalized and embodied in specific philosophies such as creationism. God, the architect of the world, creates form by first thinking about it and then imposing it on matter as a command: let there be light, let there be form. Form is thought to be primarily an idea in the divine designer's mind, and the process to embody this mental design is seen as similar to giving orders in the military, that is, a process which assumes instant obedience. One does not, of course, have to believe in creationism to subscribe to this philosophy. Platonic essences (eternal ideal forms inhabiting some other world) perform the same function as God's thoughts. In both cases, the origin of form is transcendent with matter deprived of any active agency and reduced to a willing receptacle.

Yet, as Gilles Deleuze has shown, not every Western philosopher has adopted that attitude. In philosophers like Spinoza, Deleuze discovers another possibility: that the resources involved in the genesis of form are immanent to matter itself, not transcendent. Materials have an inherent capacity for the generation of form, an inherent ability to self-organize in certain conditions. The simplest case of this capacity is illustrated by the phenomena of phase transitions. This is the scientific term to refer to the spontaneous changes which occur in the structure of materials at certain critical points of intensity, such as the condensation of steam into liquid droplets, or the crystallization of water into ice, at critical points of temperature. During these phase transitions, matter spontaneously changes architecture, from the gaseous structure of steam to the very different spatial organization of a liquid, to the more rigid architecture of a crystal lattice. Metallurgists in the past knew about these phase transitions in metals and knew that how one crosses the critical point matters. For instance, once one melts the metal it matters how fast one allows it to solidify, whether one lets it air-cool slowly or whether one accelerates the solidification by quenching it, submerging it suddenly into cold water. In one case one ends up with a more perfectly crystalline material (air-cooling allows the molecules to take their time finding their right place in the crystal lattice) and in the other case with a more amorphous, glass-like material (quenching does not allow the molecules to organize into regular arrays). For at least a thousand years before philosophers like Aristotle began their speculations, most of the knowledge about metallic phase transitions, and about the mixture of different metals (such as copper and tin) to get novel properties (in alloys such as bronze) was developed on a purely empirical basis, through a direct interaction with the complex behavior of materials. Indeed, the early Greek philosophies of matter may have been derived from observation and conversation with those "whose eyes had seen and whose fingers had felt the intricacies of the behavior of materials during thermal processing or as they were shaped by chipping, cutting or plastic deformation."

One reason for this neglect may be that the philosophy of design of metallurgists and other craftsmen was implicit (not verbally articulated). It nevertheless was a real alternative to both essentialism and creationism. Instead of imposing a cerebral form on an inert matter, materials were allowed to have their say in the final form produced. Craftsmen did not impose a shape but rather teased out a form from the material, acting more as triggers for spontaneous behavior and as facilitators of spontaneous processes than as commanders imposing their desires from above. In all this, there was a respect for matter's own form-generating capabilities and an ability to deal with heterogeneity. But is this other philosophy a thing of the past? Are we being romantically nostalgic about a golden age of non-routinized design procedures that are today inevitably lost? Or, on the contrary, is the era of steel and other homogenized materials only a passing phase which is about to be left behind by a renaissance of novel and more complexly behaved materials? James Gordon seems to think the latter alternative is more likely. The idea that a single, universal material is good for all different kinds of structure, some of which may be supporting loads in compression, some in tension, is what seems to be wrong. As in the case of biological materials like bone, new designs may involve structures with properties that are in continuous variation, with some portions of the structure better able to deal with compression while...
others deal with tension. *Intrinsically heterogeneous* materials, such as fiberglass and the newer high-tech composites, afford designers this possibility. As Gordon says, "it is scarcely practicable to tabulate elaborate sets of "typical mechanical properties" for the new composites. In theory, the whole point of such materials is that, unlike metals, they do not have "typical properties", because the material is designed to suit not only each individual structure, but each place in that structure."4

The problem is that, despite the availability of new materials with complex behavior, our design skills may now lag behind. Many centuries of thinking about the genesis of form as occurring mostly in the brain without interaction with matter have deprived us of these skills. Or more exactly, since it is not just a question of an ideology shaping our minds, several historical processes have conspired to impose the wrong philosophy of design. For example, the nineteenth century process of routinizing labor, of transferring skills from the human worker to the machine (the process which came to be known as Taylorism) and the task of homogenizing metallic behavior went hand in hand. As Cyril Stanley Smith remarks "The craftsman can compensate for differences in the qualities of his material, for he can adjust the precise strength and pattern of application of his tools to the material's local vagaries. Conversely, the constant motion of a machine requires constant materials."5 Given that much of the knowledge about the non-constant behavior of materials was developed outside science by empirically oriented individuals, the deskillling of craftsmen that accompanied mechanization involved a loss of that know-how. And since that loss was directly related to the needs of command and control, we have here an example not only of a philosophy of design but of a politics of design.

Gilles Deleuze has attempted to change the dominant philosophy of design, or more generally, the dominant philosophy of the genesis of form, by recovering some of the experience of the old metallurgists and developing it in a more abstract way. He uses the term "machinic phylum" to refer to the world of matter and energy when it is conceived without an architect God (or any other transcendental source of form, such as essences). By the term "machinic" he means simply "the articulation of heterogeneities as such", that is, the creation of form with materials that have not been made obedient by homogenization.6 The term "phylum" he takes from biology where it means the category just below "kingdom". We as vertebrates, for example, belong to the phylum "chordata". But beyond being the name for a category, phylum means a particular body-plan, an *abstract architecture* from which we can obtain, via different embryological processes, a large variety of concrete architectures: if we fold and stretch a fertilized egg following a certain sequence we get a giraffe; follow another sequence, we get an elephant; yet other sequences yield all the different architectural structures of the other vertebrates.

When the two words are put together, "machinic phylum" means that there is just one body-plan not only for animals, but also for plants, clouds, winds, mountains etc. All these different structures would, if Deleuze is right, stem from one and the same abstract architecture. One universal phylum would be divided into many more specific phyla, including the different lineages that make our technologies. Each phyla would be characterized by their phase transitions [which Deleuze calls "singularities"] and by the properties which materials acquire as they cross those critical points [properties which he calls "traits of expression"]). To quote him in full: "Let us return to the example of the saber, or rather of crucible steel. It implies the actualization of a first singularity, namely the melting of the iron at high temperature; then a second singularity, the successive decarbonations; corresponding to these singularities are traits of expression—not only the hardness, sharpness and finish, but also the undulations or designs traced by the crystallization and resulting from the internal structure of the cast of steel. The iron sword is associated with entirely different singularities because it is forged and not cast or molded, quenched and not air cooled, produced by the piece and not in number; its traits of expression are necessarily different because it pierces rather than hews, attacks from the front rather than from the side... We may speak of a machinic phylum, or technological lineage, wherever we find a constellation of singularities, prolongable by certain operations, which converge, and make the operations converge, upon one or several assignable traits of expression. If the singularities or operations diverge, we must distinguish two different phyla: that is precisely the case for the iron sword, descended from the dagger, and the steel saber, descended from the knife... But it is always possible to situate the analysis on the level of singularities that are prolongable from one phylum to another, and to tie the two phyla together. At the limit, there is a single phylogenetic lineage, a single machinic phylum, ideally continuous: the flow of matter-movement, the flow of matter in continuous variation, conveying singularities and traits of expression."7

The design philosophy which a theory of the machinic phylum implies goes directly against the idea of form coming from the outside to shape an inert material, and implies a certain respect for the inherent shape-generating capabilities of matter. Speaking of the relation of carpenters to wood as an active material, he says "It is a question of surrendering to the wood, then following where it leads... But it is always possible to situate the analysis on the level of singularities that are prolongable from one phylum to another, and to tie the two phyla together. At the limit, there is a single phylogenetic lineage, a single machinic phylum, ideally continuous: the flow of matter-movement, the flow of matter in continuous variation, conveying singularities and traits of expression."8

5 Cyril Stanley Smith. op. cit. Page 313.
8 Ibid. Page 408.
fibers of the wood, without changing location... [But] artisans are obliged to follow in another way as well... to go find the wood where it lies, and to find the wood with the right kind of fibers.  

The know-how and sensual knowledge characteristic of craftsmen then, needs to be placed in the context of a world where matter and energy (the overall machinic phylum) are full of capabilities to differentiate into a multiplicity of phyla (some geological, some biological, some technological) and where creative tinkering and trial and error can track the lines of development inherent in the machinic phylum. The old design philosophy and to "track the machinic phylum", in order to create structures with more complex behaviors, I would like to discuss here several of these innovations, including the use of flexible surfaces of revolution, so called because they are generated by spinning a line. Another simple operation, called "extrusion", begins with a surface or a cross-section and generates a three-dimensional shape by displacing it or scaling it, while at the same time providing new side surfaces to complete the solid form. In both cases only a very small repertoire of shapes may be created. This reduced variety may be increased somewhat by including "Boolean operations", which allow the designer to combine several forms generated by revolution or extrusion.

For example, one may carve out a round hole into a solid shape by using a cylinder and the Boolean operation of subtraction, which removes material from the solid shape in the form of another solid shape. All these primitive operations are standard in most CAD packages. They implicitly embody one of the two design philosophies I mentioned before: one basically imposes a form on a virtual material, rigid polygons, which is completely inert. The first departure from the world of obedient rigid polygons was represented by special flexible curves called "splines". These curves already contain a kind of singular behavior. In this case, of course, a "singularity" does not refer to critical points defining a phase transition, but to the special points that define a curve, such as the inflection points at which a curved line changes direction. When curves are defined by their singular points (inflection, maxima and minima points) they become a little more "alive", a little more plastic, since one curve can be continuously deformed into another and will count as the same curve as long as it contains the same singularities. (We can think of these curves as deformable French curves.) When the same idea is applied to surfaces, the virtual patches inherit the flexibility of the curves and the designer must begin to respect some of the inherent behavior of these surfaces (called Bezier patches or in most advanced software, Nurbs, Non-Uniform- Rational Bezier-Surfaces).

The basic idea behind a spline is that the designer does not specify every single point of the curve, but only a few key weights which deform the curve in certain ways. The software then displays the simplest curve, the one with the most streamlined shape, which matches those weights. One can, of course, add so many weights that the curve becomes very difficult to define at each point, but then one loses the streamlined form. In other words, the designer may impose his or her will at every point, defining the form in minute detail, but then the inherent tendencies of the spline to "seek" the most efficient curve are lost. And a similar point applies to surfaces: to take advantage of their intrinsic capacity to bend in the most streamlined way designers need to refrain from imposing too many constraints on them, else they might as well go back to the rigid, polygonal surfaces of the earliest CAD packages. A more extreme departure from the old paradigm is embodied in more recent software, such as Particle Dynamics. The original purpose of this software was to generate forms which are not solid, such as fire, wind, snow, rain or any other mobile pattern which involves a large population of constantly changing small particles. Here one begins not with an obedient piece of clay which may be molded in any way one wishes, but with a flow of pixels which, in order to be shaped, must be caught in one of several available fields: a gravitational field, a vortex field, a turbulent field and so on. The pixels [or
smaller picture elements] can be given a history specifying what happens to their properties (color, transparency) as they flow. For example, to create fire one begins with a pixel flow in which the color is specified to begin stark white [at the hottest point of the fire] and change slowly to yellow, orange and red. The transparency is also specified to begin fully opaque and end fully transparent, so that particles disappear as they get further away from the source. Finally, one traps this flow into a turbulence field and manipulates some knobs which specify certain properties [such frequency or amplitude] which determine how tame or wild the resulting flames will be. In this process, the designer is not imposing a predefined form but attempting to tease out or elicit the emergence of a changing form from a flow which has its own intrinsic behavior. Here the challenge for designers is to invent novel uses for this software, that is, uses which do not involve the simulation of fire or rain, but that go beyond these original applications.

But perhaps the greatest challenge to designers will be when Genetic Algorithms become a standard part of CAD programs. Unlike the two design tools I just described, this software was created not to aid designers but biologists in understanding the dynamics of evolutionary processes. Basically, the software allows the definition of a virtual form by a set of instructions, and the transformation of those instructions into the genes or DNA of the form. Then, the software allows those virtual forms to sexually mate with one another, recombining their instructions as they give rise to varied offspring. The Genetic Algorithm keeps track of what virtual form mated with what other form and which new instructions. When used as a design tool [as it has been done by artists such as William Latham10] the designer's role is to decide, at each generation, which forms will survive and which will die, or in other words, the artist's role is to guide the evolution of these forms. In performing this guiding task the designer becomes a kind of animal breeder: a dog or horse breeder can hardly impose a predefined form on his animals and at best plays the role of an aesthetic judge. In other words, the artist's role is to see singularities (phase transitions) as a key component of what the machinic phylum is. I gave one example, the simplest type, of these metamorphosing transitions: liquification or crystallization. It is here that Deleuze and his philosophy of form will become necessary. As I said above, Deleuze sees singularities [phase transitions] as a key component of what the machinic phylum is. I gave one example, the simplest type, of these metamorphosing transitions: liquification or crystallization. But there are many others, such as the transition in a metal from magnetic to nonmagnetic, the transition in a flowing liquid from calm to turbulent, or the transition in the gait of a moving horse from trotting to galloping. In the study of real embryological development it has become clear that the embryo goes through an elaborate sequence of phase transitions, some of which divide the fertilized egg, others which change its symmetry from spherical to bilateral, others yet which mark the onset of the development of an arm or a finger. With each singularity crossed new traits of expression [to use Deleuze's term] emerge and become the stage for yet other phase transitions, each singularity adding complexity to the initially simple egg. Yet the egg itself, and its distribution of intensive

properties (such as the intensity of concentration of certain chemicals) already has the capability to undergo those metamorphoses. The genes guide but do not command the final form. In other words, the genes do not contain a blueprint of the final form [a blueprint which would be an external form imposed on the egg] but tease out that final form from the egg by facilitating a phase transition here, inhibiting another one there, maneuvering the dynamic development process in certain directions and away from others.\textsuperscript{11}

Architects and structural engineers will need to learn from real embryological processes, or to put it differently, they will have to become egg designers. In this case the distribution of intensive properties will not be one of chemical concentrations, but the \textit{distribution of stresses} which any load-bearing structure exhibits. In other words, in order for a building to evolve as a building, the columns [and the distribution of stresses produced by compressive forces] will have to be constrained to remain columns, unless other structural elements have evolved which change the stress distribution taking the load off the column and allowing it to become a decorative element evolving along purely aesthetic lines. And similarly for beams and other structural elements. The virtual evolutionary process will have to take place via phase transitions, with each singularity marking the emergence of a new structural element and a new distribution of stresses, and something within the software will have to ensure that the combination of structural elements remains coherent. Clearly, performing all these tasks will involve going beyond the capabilities of most existing CAD programs. But when such a software is created (and I am sure that it will) the philosophy of form it will embody will be far away from that of the original CAD packages which worked with rigid polygons, the virtual version of obedient matter. Both the design of the software and the design of the eggs themselves will involve using know-how and skills to “track the machinic phylum”, that is, to investigate the behavior of simulated evolution past certain singularities and the emergent wholes arising from the interactions between many components. It will also involve a cooperation between the designer and the virtual materials, a process where all parties have a say in the final form produced.

VERB PROCESSING

001-075 FOA Yokohama International Port Terminal
Texts by Alejandro Zaera-Polo and Kunio Watanabe
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Urban soundscape
092-115 B&K+ Telematic landscape, Kölner Brett building
116-129 NOMAD Urban hybridization process
Kindergarten in Sondika
130-143 MANUEL DE LANDA Philosophies of Design
The case of modeling software
144-207 INSERT Ljubljana, Graz, Zagreb
208-219 SADAR VUGA ARHITEKTI
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