A Periodic Table of Form:

The secret language of surface and meaning in product design

Why does Design so often struggle to communicate its value to the world, when it's something we all recognize?

When we speak of product development, we frequently look at the domains of Design and Engineering separately, evaluating them in different ways. Engineering, at its core, is a measurable process; Design, for the most part, is not. This gives the former an inherent advantage: engineering efforts are easily quantifiable, and this provides them with authority. Design is intuitive, working on the non-verbal levels of our experience, sometimes triggering our most subversive emotional states; this makes it difficult to evaluate empirically. Lacking an analytical vernacular, Design is labeled subjective, when it is actually the agent of universal truth through form.

The consequences of interacting with the array of sharp spines on a sea urchin or porcupine are pretty obvious to any creature passing by--you don't need a pair of frontal lobes to understand this.

For the consumer, it's easy to forget how much the emotional response to an object determines his or her relationship to it, but this forgetfulness can be plausibly explained by the dominant role our analytical mind plays in formulating language. Because it is *able to say* it's in charge, as the executor of structured argument, the analytical mind generally convinces us that it *is* in fact the authority. Reasoning therefore holds higher status, and emotional reactions are easy to dismiss as immature or irrational. This poses a very real

barrier to the acceptance of design as a source of value in product development; enough that it's worth examining alternate ways of evaluating design, transcending this subjective view to create a more universal system of measure.

Form has meaning; it can touch us at such a primal level that our mind is left scrambling to rationalize our emotional reactions. Consider the visceral impression conveyed by a natural setting: The deep serenity felt, for example, while walking through a majestic grove of redwoods. The delicate lace of fern fronds wave as you drag your hand through them as you walk, and your heart jumps into your throat when startled by a deer caught wondering across the trail. These natural forms hold an innate meaning that not only transcends the human experience, but even predates our verbal expression, definition, and measurement. In other words, *we* did not create this meaning; it comes from the forms themselves, and existed long before we did.

What Surface Continuity is Quietly Telling Us

For the purpose of this argument I propose that form (or *Design*), in the context of both the natural and man-made world has two jobs: *to be the messenger of a certain experience*; and to *fulfill on that promise*. When the two don't match up, the experience is unfulfilling and its form superficial. Consider the agreement between message and experience in these examples from nature:

Meaning in Nature

- The vibrant color and markings of the poison dart frog warns off predators with the promise of death; fulfillment here is clear.

- The Monarch Butterfly's colorful markings also flaunt its poisonous nature; their purpose is attained when predators are deterred.

- The consequences of interacting with the array of sharp spines on a sea urchin or porcupine are pretty obvious to any creature passing by--you don't need a pair of frontal lobes to understand this.

- The glorious display of the peacock's plumage carries the clear message, 'my DNA is better than the next guy's, so mate with me'.

- The elegant complexity of sexual reproduction in flowering plants is one small indicator of co-evolutionary ecologies, one of the most awe-inspiring truths in the natural world.

- Even the sinister bio-mimicry of the Preying Mantis, luring unsuspecting pollinators to their death, has a beautiful symmetry to it.

These mutually arising, mutually "designing" attributes of nature tell a story of the effect of form on life itself, which predates the defining nature of our verbal language. In our language-based society though, it is the power of visual design and subsequent eloquence of non-verbal communication can easily escape us.

Conspicuous is the nearly complete absence of tangential forms in nature.

If there is an empirical meaning behind form then, how does it manifest across the natural and into the man-made world? Going further with this notion, let's deconstruct the meaning of form naturally, and then distill that meaning into some simplified geometric categories technically. In order to define these categories, I will ironically employ a three-level definition of surface continuity from the engineering CAD lexicon: **Positional**, **Tangential**, and **Curvature** continuities.

It's useful to think of these three types as steps in a ladder, with each building on the definition of the last. **Positional continuity [C^0 or G^0]** refers to the hard edge created when 2 surfaces intersect. **Tangential continuity [C^1 or G^1]** is the next level, defined by a circular arc creating a relatively smooth transition between these surfaces. The quality of this transition is best visualized by a straight line drawn between two circles: the line's only point of contact with each circle is tangential. This level of continuity is often described as a basic

fillet in most solid modeling systems. Although smooth, there is a characteristic "break line" of tangency denoting where the circle meets the line.

Curvature continuity [C² or G²] is a bit trickier to describe. Technically, it occurs when the rate of curvature between 2 continuous surfaces are the same. Visually, it is when one cannot tell when one surface ends and another begins. In the CAD world this is often referred to as *class A surfacing*, and is the domain of surface-based modeling software like Alias, Rhino, and Catia. The primary benefit of Curvature's quality is the ability to control smooth reflections across multiple surfaces, generating the elegant sculptural results necessary in the automotive industry. The technical renderings below illustrate these visual qualities better than any verbal description could. Please pay attention to the subtle differences, particularly the Tangential line marking the fillet's point of contact with its adjacent surface, and how the reflections break there as well.

Quality of Surface Transition

C^0	C^1	C^2
Positional	Tangent	Curvature
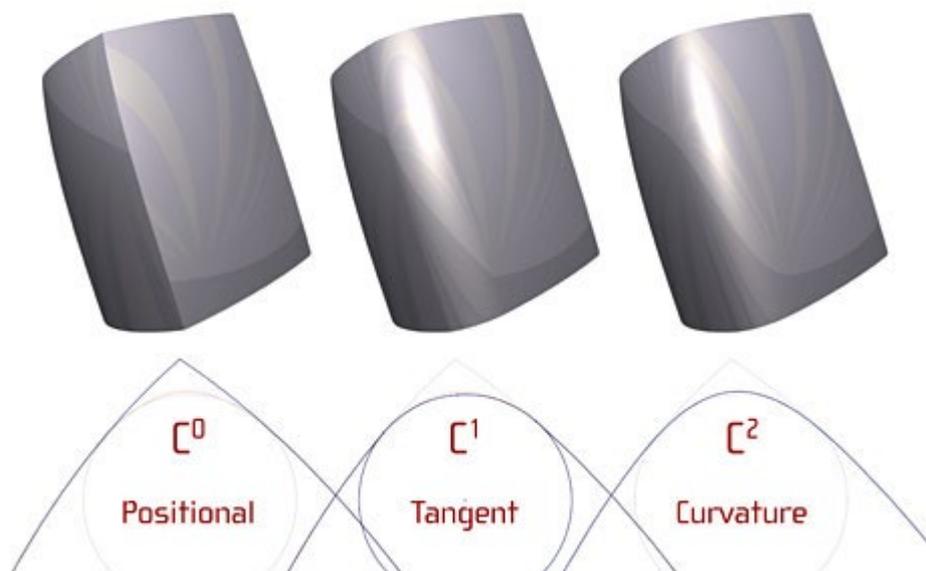
Technical Continuity Evaluation

C⁰ Positional
C¹ Tangent
C² Curvature
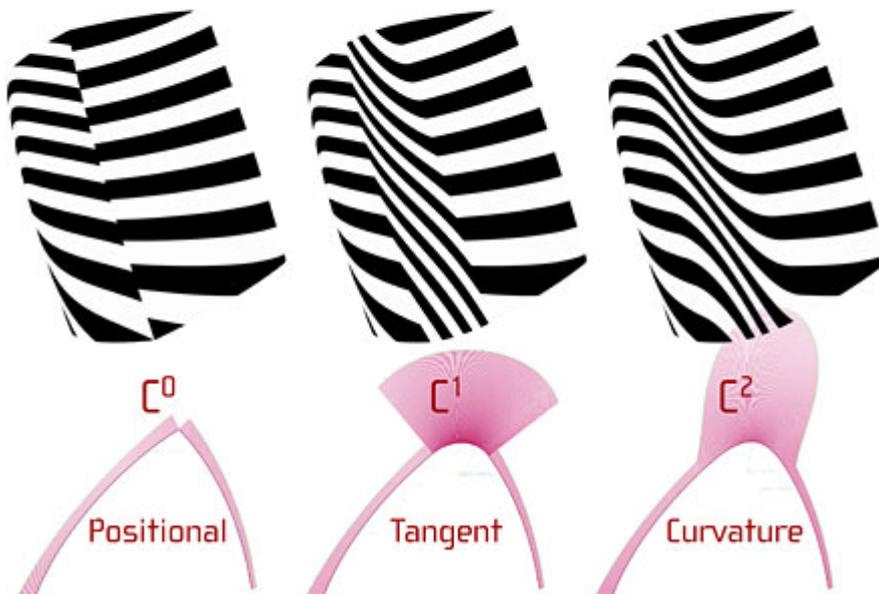
Looking at the diversity of nature yields numerous examples of both Positional and Curvature continuity: from the sharp edges of crystal formations, the jagged fans of palm trees, and the serrated scales of thorny lizards; to the aqua-dynamic skin of a dolphin, the flowing shapes of sedimentary sandstone, and the graceful curves of a flower petal. Examining our emotional responses to these two classes of natural form development, there are distinct sets of impressions they leave upon us:

The Positional forms suggest *precision, accuracy, danger, structure, fidelity...*

The Curvature surfaces intimate *sophistication, elegance, fluidity, grace, refinement...*

Conspicuous is the nearly complete absence of tangential forms in nature.

Continuity in Nature

Positional   Tangent   Curvature

Meaning and the Man-Made Formscape

Now taking this same simplified approach to the categorization of man-made forms, especially transportation machinery, we can see similar patterns of meaning arise. The Stealth Fighter and the Cadillac show-car both have a *menacing* and *precise* nature. The D-type Jaguar and the B-1 Bomber hold an *alluring* yet somber *elegance*.

Newer to this form-scape are the Tangential forms, and notably they have a very particular and consistent point of view: they all maintain a sense of *utility, function, efficiency, practicality, purpose...* The design language of these SUVs epitomized the notion of *purposefulness*, even when comparing the utilitarian nature of the original Land Rover with its glitzy new cousin the LR3 Discovery. Remarkable is the same *functional* character of the CV 22 Osprey; one would think that the laws of aerodynamic would solely determine this airplane's shape--no industrial design team sketched up this form language--yet one can plainly see the *utilitarian* message of this vehicle expressed in its form.

Continuity in Transportation Design

Positional   Tangent   Curvature

Stepping into the terrain of product design, we see a different distribution of this continuity landscape. On the Positional end of the spectrum, we again have products of *precision and fidelity*. On the other end we have C^2 objects of *elegance and sophistication*. And clumped on top of each other in the middle are the majority of Tangential consumer products.

There is a profound laziness to the execution of these products, especially when compared to the beauty of diversity found in nature.

Now here's the rub: How many of these are appropriately utilizing the form language of *utility* and how many are not? How many are tangentially sculpted because of the tools of creation (tangent-restricted solid modeling software)? How many are consciously designed to produce a relevant user experience? The DeWalt drill of course is right on the mark, the Emeco Navy Chair absolutely shouts utility, and all of the Dyson vacuums are Tangent porn as far as I can tell--functional engineering taken to a styled perversity--but it is the hoards of cell phones, MP3 players, computers, and multitudes of consumer electronics that lack much distinction or differentiation from each other. There is a profound laziness to the execution of these products, especially when compared to the beauty of diversity found in nature. You could easily argue that a majority of products are primarily tools of purpose, and thus Tangent is their true form language. Unfortunately, too many products are unconsciously executed with the engineering tools at hand, instead of looking for the nuanced and subtle differences that would make them worthy of the space they take up on the shelves of our consumer market place.

Continuity in Product Design

Positional   Tangent   Curvature

Now, understandably many of these products are not so much Designed as driven by engineering requirements, cost, and short timelines. They were created, but without Design in mind. Functions and features most likely dominated the development process rather than ease of use and quality of experience. I would venture again that the user was not really put at the forefront because it is not ease to measure their experience, thus the "rational" mindset ends up driving development by functionality alone because it is simple to quantify. Also much of the "piling up" of Tangentially formed products today is directly proportional to the tools (solid modeling software) that designers and engineers are using to conceive and implement ideas. So development tools and marketing features are dictating customer experiences instead of the other way around.

Remember that the Tangent category does not exist in nature in pure form: it is a mental construction from man's imagination; an abstraction of functional form designed to simplify the task of product development. Predating CAD, this geometric linear- and arc-based approach evolved out of the mental constructs of design technique, industrial fabrication, and reproduction of the objects of the 20th Century. It was the root of the Bauhaus ideal: the single language of "form following function." And while I have a deep affection for the pragmatism embodied in that phrase, I find it too limiting. It just doesn't hold universal truth, rooted as it is, exclusively in the world of measurement.

The Periodic Table of Form

Is Design merely inspiration's anatomy without reason or rationale, or is this rooted in some universal truth? Can we apply a scientific method of measure, and give order to form's relationship with meaning? While struggling to come up with some concrete examples to these questions, the team at Alchemy Labs decided to "make" some generic widgets to illustrate our collective thoughts on this matter.

We started with a deceivingly functional form: a simple shape that, to fool the viewer's eye, looked like it did something, but in fact has no function at all. Then we applied the three categories of continuity to form a baseline structure. Then, in Darwinian fashion, we cross-pollinated these central forms to create hybridized form statements. The result is the beginning of a kind of Periodical Chart of Forms that can be parsed for their associated Meanings. Like the Periodic Table of the Elements, this system holds ample opportunity for mixing proportions, creating alloys, and adding impurities. We propose that this visual paradigm has room to house all the things that have been, and the things yet to be.
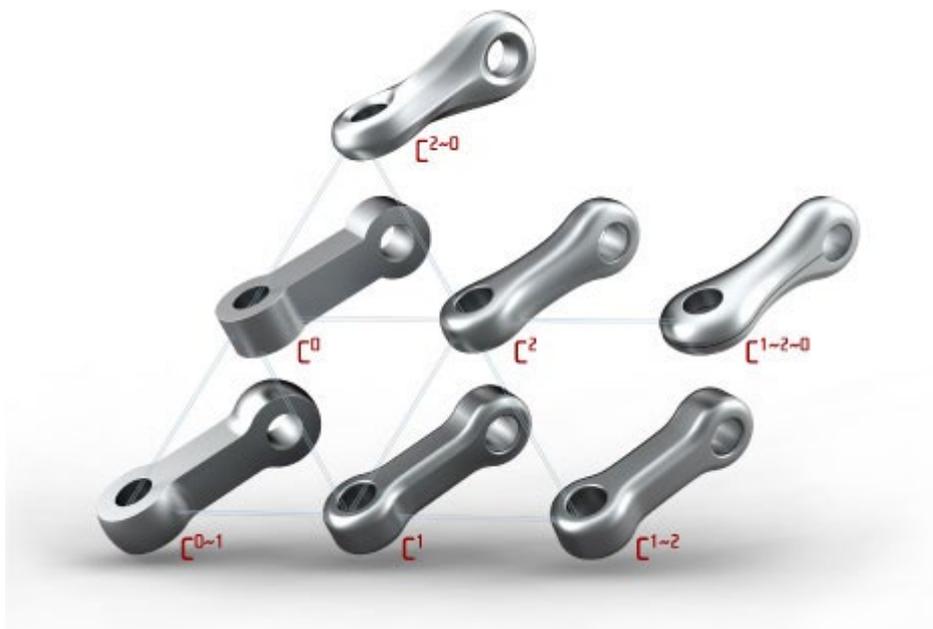
Once established, we can test the paradigm with some concrete samples, validating it through blending the 3 levels and then deconstruct their complex hierarchical meaning.

It's interesting to see these two products side by side, the 2001 PowerBook now seems a bit simplistic in comparison to the 2008 MacBook Pro.

We start with the F-22 Raptor, the newest fighter in the US Air Force arsenal. This jet's integration of stealth technology and slippery aerodynamics is faithfully expressed in its contrasting *angular* Positional silhouette and *graceful* Curvature control surfaces. The blending of these two continuity levels produces a *sophisticated, exacting, and formidable* visual specter.

Like the F-22, the Lamborghini Reventon is a fusion of Positional and Curvature form development, but its origami-like folding of sleek surfaces signies a threatening yet exotic precision; a technological sex appeal that cuts both ways.

Apple's PowerBook represents the other end of the spectrum: large friendly radii and Bauhaus minimalism, these transitions are deceptively *sweetened* with the subtle Curvature quality fillets. The result is a Design language that says, "I'm simple to use, thoughtful, and sophisticated." Apple's excruciating attention to this level of detail is at the heart of this brand's customer experience and behind their consumer cult loyalty; their commitment to crafting this experience says simply that they care more about their consumer than their competition.

How has Apple's design language evolved with the introduction of the new MacBook Pro? Again the first layer is minimalistic Tangency with the intrusion of Curvature transition quality, but this latest version brings in Positional "bone lines." These additional *cutting*

features evolve Apple's sophisticated ease of use into a more "mature" precision design statement. This echoes from its new high-fidelity machined chassis, representing the most exacting manufacturing process of any laptop made today. It's interesting to see these two products side by side, the 2001 PowerBook now seems a bit simplistic in comparison to the 2008 MacBook Pro.


PowerBook 2001

MacBook 2008

No matter how much our mind wants to control the conversation, we will miss out on at least half of the story if we don't recognize and honor our emotional side of our being. Product development needs to take a more harmonizing approach, through a more

seasoned awareness of our true nature and a deeper look into creation, assessment, and valuation of both our mental and emotional bodies.
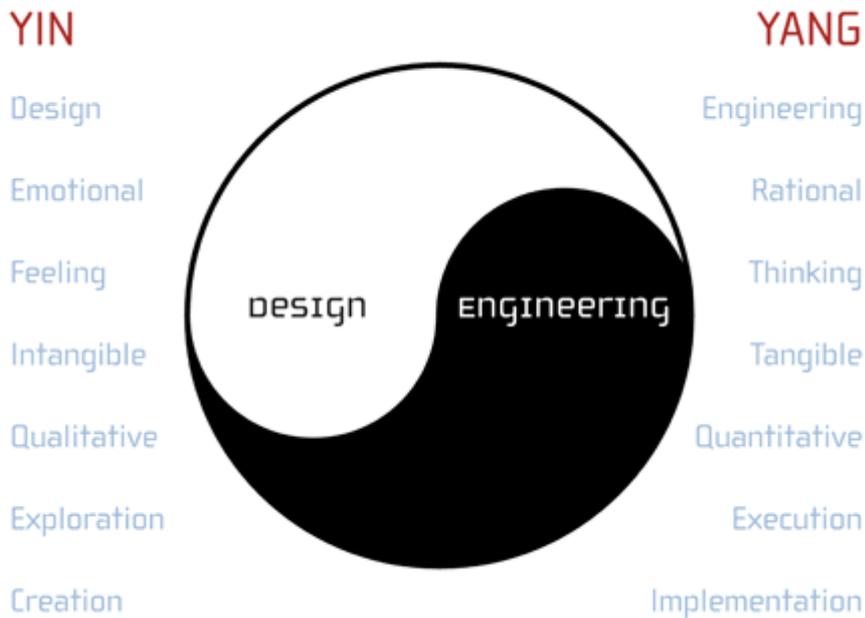
The Periodic Table of Form & Meaning is an attempt to address certain goals: to create a model of empirical understanding for three dimensional form, to start defining Design's intangible traits, to measure its emotional meaning in such form, and to *make conscious some of our unconscious choices*. We need to embrace the completeness of the being of form, by more consciously and thoroughly understanding it, and not focus merely on only the consciously measured half of the story. This simple yet open structure hopes to create a dialogue between the heart and mind, in form in particular, but in ourselves primarily (by the necessity of our task). Thus, we can make a case for Design's true value, and petition our ruling rational thought processes to loosen their grip: to allow us to stop and smell the *truth of beauty*, and the *beauty in truth*.