Systematic Innovation

e-zine

Issue 201, December 2018

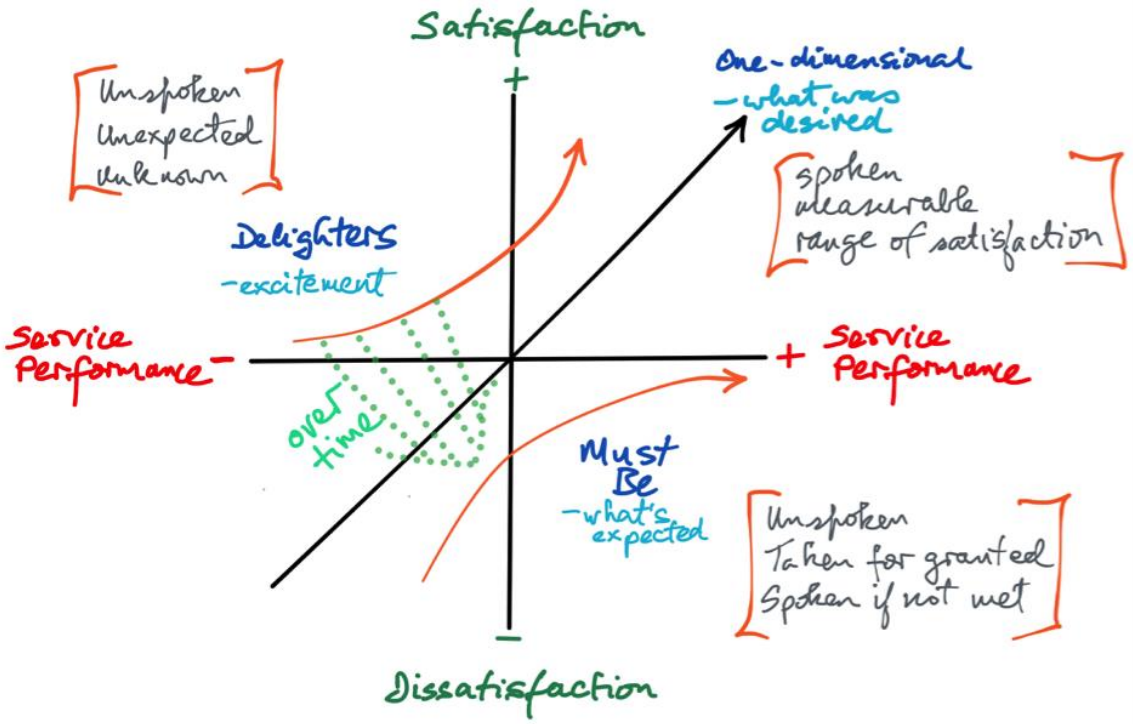
In this month's issue:

The Systematic Innovation e-zine is a monthly, subscription only, publication. Each month will feature articles and features aimed at advancing the state of the art in TRIZ and related problem solving methodologies.

Our guarantee to the subscriber is that the material featured in the e-zine will not be published elsewhere for a period of at least 6 months after a new issue is released.

Readers' comments and inputs are always welcome.
Send them to **darrell.mann@systematic-innovation.com**

Kano & Intangibles



I'm never sure whether the Kano Diagram (above) has fallen from favour and disappeared, or whether it has become so ubiquitous that no-one feels a need to talk about it anymore. If I had to place a bet, I'd say that the answer was more likely to be the former than the latter. Mainly because I think that, even though most people that see the model instinctively 'get it' conceptually, it is a different matter to turn the concept into something that gives innovation teams anything meaningful to get their teeth into. Sure, creating more 'delighters' is a good thing to do, but what kind of delighters are we talking about? In this sense the model is a classic example of the 'insert miracle here' kind of creativity tool. The model tells us to look for delighters, but doesn't tell us where or how to look.

I also think that it is somewhat incomplete. That or else maybe time has moved on. The idea of the three different types of improving feature – delighters, performance ('one dimensional' in the above version of the Model) and basic ('must be's) needs the addition of a fourth. The first three form a kind of an evolutionary sequence, in that a feature that delights a customer today, is unlikely to still do so in a few weeks' time. Delighters devolve to things that customers 'expect' to be present, and these in turn devolve to being things that we only notice and get annoyed about if they're not present any more. If we continue this feature 'devolution' journey, there are also features that become irrelevant. I expect my car to have four wheels, but I no longer care if it has a cassette player in it.

The addition of a fourth part to the Kano story conveniently allows for the creation of a meaningful 2x2 matrix. The two dimensions of this matrix relate to satisfaction and dissatisfaction. Although the pair might at first glance appear to be two ends of the same axis, by positioning them as two orthogonal axes it becomes possible to visualize situations where, for example, customers can experience both high satisfaction and high dissatisfaction. The four quadrants of this satisfaction/dissatisfaction matrix then relate to the four types of design feature like this:

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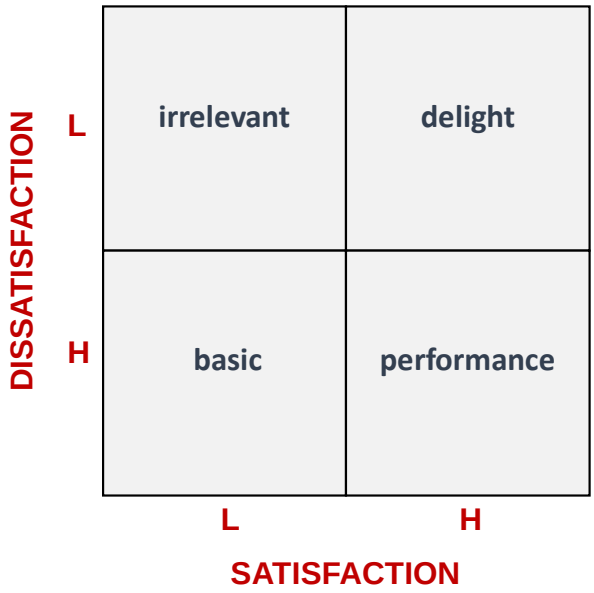


Figure 1: 2x2 Matrix Version Of Kano Diagram Showing 4 Improvement Feature Types

And once we have this model, we can see how a customer's perception of the different improvement feature types devolves over time. At first something might 'delight' us. Delight is all about high satisfaction and comes with little or no element of dissatisfaction since we didn't expect to see the delighter and therefore don't miss it if it happens not to be there. The delight emotion tends to be relatively transient in nature, and sooner or later devolves to the 'performance' category. This is where a customer may experience satisfaction or dissatisfaction depending (approximately linearly) with the amount of the feature they do or don't receive. Later still, at the basic, 'must be' stage, the satisfaction component disappears and the only emotion the customer might experience is the dissatisfaction that comes if the expected feature is no longer there. Finally, then, comes the 'irrelevant' quadrant, the final devolution of a design feature to the point where, like the redundant in-car cassette player, it neither satisfies nor dissatisfies. The overall devolution trajectory thus looks something like this:

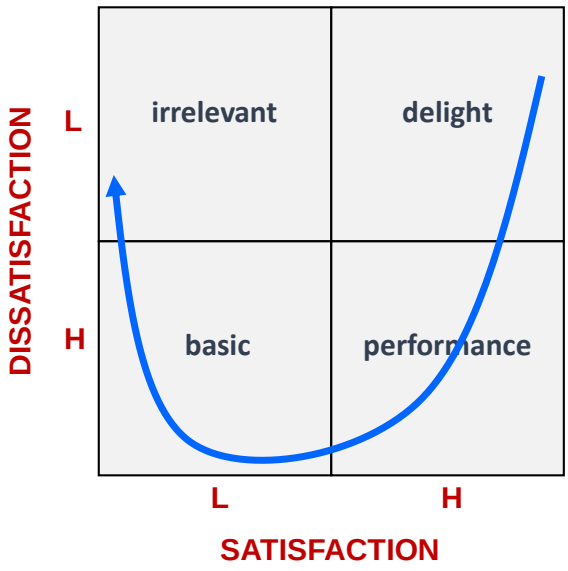


Figure 2: Dynamics Of (4) Kano Diagram Improvement Feature Types

The main value of the 'irrelevant' quadrant is it reminds us to think about attributes and features of an existing design that might have become redundant and thus may be

considered for elimination from the system. It gives us a little more granularity around the ‘insert miracle here’ problem, but not much. We still have no idea, for example, about what new features we might look to introduce to a system, or how much of them we might look to offer to our customers.

To begin to solve this problem, it is necessary to integrate the 2x2 matrix into another one. When making models more complex than they currently are, we should always be wary, since it can easily become the case that we will put people off using the tool. Fortunately, in this case, the 2x2 matrix we need to integrate the Kano version into is one that TRIZ/SI users will very likely already be familiar with. The matrix in question is our Outcome Map, and the combined version might look something like this:

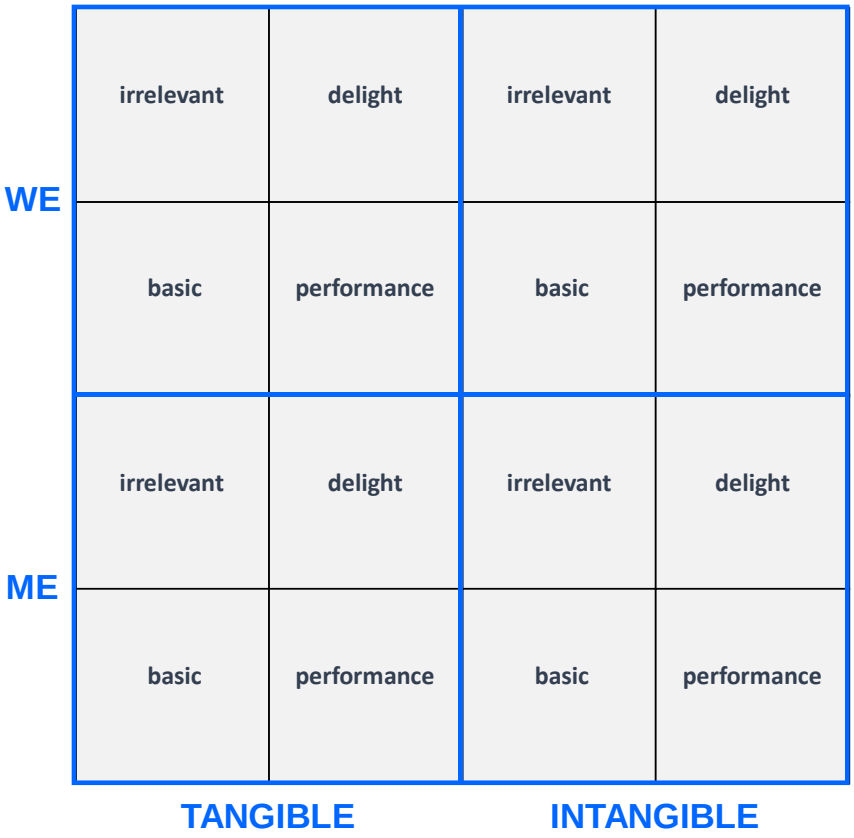


Figure 3: Integrated Kano 2x2 And Outcome Map

If thoroughness is an objective, thinking about and potentially filling all sixteen of these boxes is probably the very definition. Especially if we extend the story – as we no doubt should if we find ourselves working on a real project – to also constructing the picture for each individual ‘me’ stakeholder, at each Moment of Truth.

This is perhaps what Thomas Edison meant when he talked about innovation being 1% inspiration and 99% perspiration. Except we haven’t started to do any of the hard work of actually building and testing whatever ideas the analysis might throw up.

It’s a guarantee (from me) that the ‘a-ha’ insight will happen in at least one of the boxes in the overall array of boxes. If you’re as lazy as I am, however, it’s unlikely that you’ll have the energy or persistence to give them all the justice they deserve. In which case, you either spread the load across multiple different team members, or, if you don’t have the luxury of having a ‘team’ to do the analysis with you, you can focus on the boxes that are more likely to deliver the insights. It’s still early days for this tool, but we already clearly know that, because the biggest innovations often start with the solution of a contradiction,

and that in turn offers up some kind of new ‘delighter’, the two most important boxes in the model are these two:

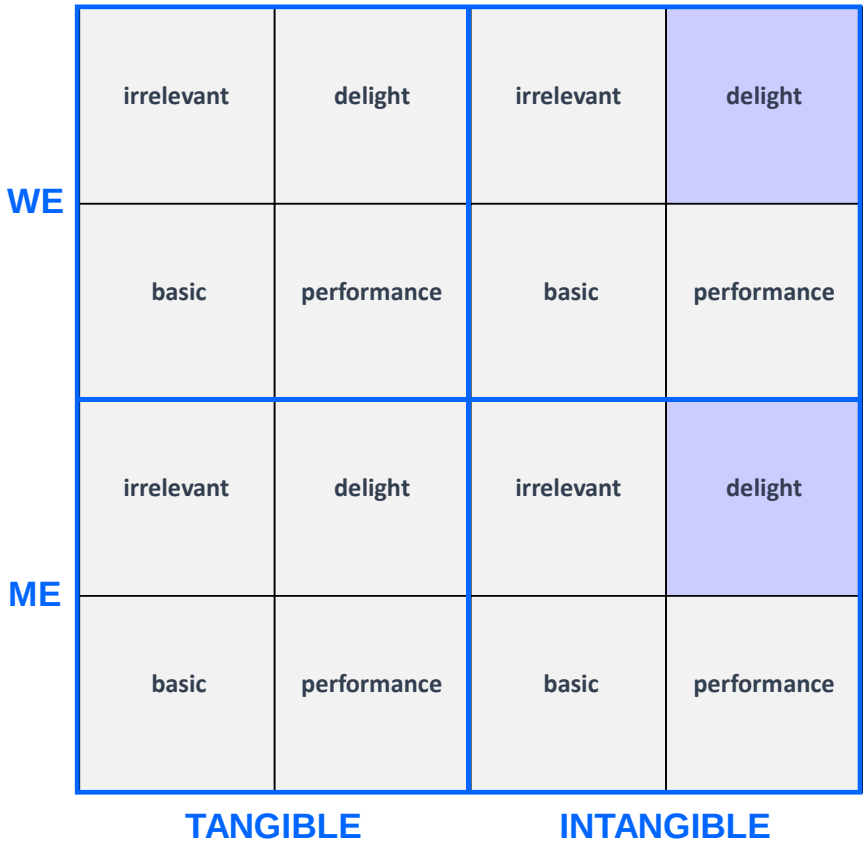


Figure 4: Integrated Kano 2x2 And Outcome Map – Best Bang-Per-Buck

And if this still doesn’t do a good enough job to close the gap between problem definition and generating the right solution, all we need to add to this story is the recognition that, when it comes to the ‘intangibles’, and moreover, intangibles at the first principle level, humans are pretty simple creatures: we want more Autonomy, Belonging, Competence and Meaning. ABC-M.

The find-the-delighter questions thus become:

- What new feature or attribute would give an Autonomy delight for the individual?
- What new feature or attribute would give an Autonomy delight for the people around them?
- What new feature or attribute would give a Belonging delight for the individual?
- What new feature or attribute would give a Belonging delight for the people around them?
- What new feature or attribute would give a Competence delight for the individual?
- What new feature or attribute would give a Competence delight for the people around them?
- What new feature or attribute would give a Meaning delight for the individual?
- What new feature or attribute would give a Meaning delight for the people around them?

Hopefully, now we’re close enough that designing for intangible-delight is well within the realms of possibility. Next month, an example. For now, an opportunity for readers to think about using the questions on an example of their own.

The Zero-Variation-Manufacture Contradiction

I spoke at a Robust Design conference last month. One of the other speakers was extolling the virtues of ‘zero-variation’ manufacture (Reference 1). The concept immediately struck me as one of those naïve, ill-conceived motivational posters the manufacture sector occasionally falls into the trap of promoting (‘zero defects’, ‘zero waste’, ‘zero breakdowns’, etc, etc). It also struck me as having nothing at all to do with creating systems that are more robust. Unless, of course, we take the definition of ‘robust’ that means everything operates okay until a catastrophic failure occurs. It felt like there was a need to do some deeper thinking.

On the positive side of Zero-Variation Manufacture (ZVM), I’m inclined to think about the old automotive industry story from the 1980s where one of the US manufacturers had occasion to compare US-made and Japanese-made versions of a particular gearbox design. The Japanese boxes were turning out to be significantly quieter, smoother and more efficient than their American analogues, and so management instructed that a number of gearboxes be stripped down and inspected to try and work out what the differences were. The results were unequivocal. All of the components from all of the gearboxes were within the stated manufacture tolerances. Every gearbox was compliant.

But then, when the team decided to look more deeply into the details, it was also clear that the dimensions of the Japanese-made components were consistently much closer to the nominal drawing dimensions than those of the American components. The only difference between the two manufacturers, in other words, was that the Japanese components had much smaller variation than the American ones. The story subsequently came to highlight a subtle but significant difference between Japanese and American manufacture philosophies: In Japan the aim was always to achieve the precise target, as opposed to the US, where so long as things were ‘within tolerance’ everything was good:

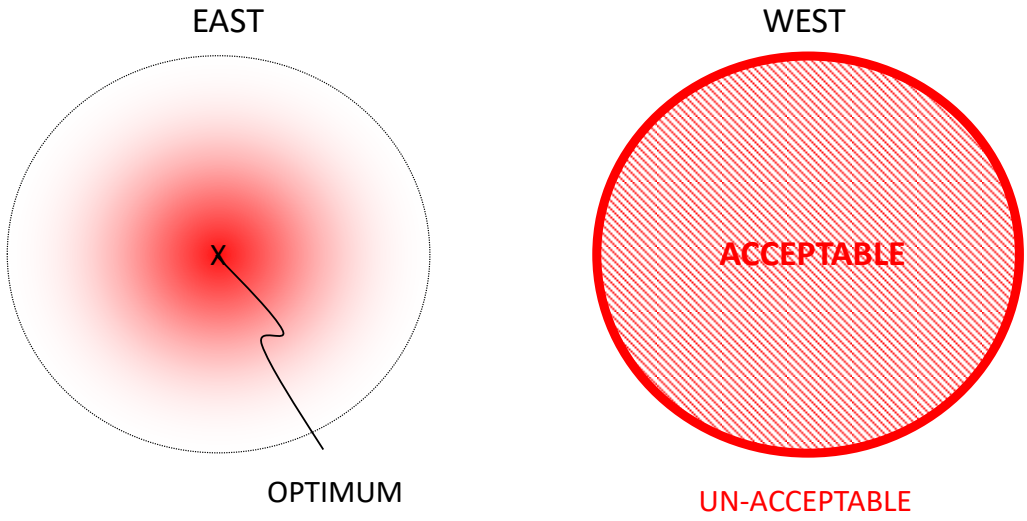


Figure 1: Difference Between Eastern and Western Manufacture Philosophies

Variation-wise, the clear conclusion the story points towards is that ZVM is a good thing.

So far so good. But, unfortunately, the world of reliability does not quite operate as simply as this. Reliability is all about designing the system as a system, and as such it is not possible to separate the world of manufacture from the rest of the business. By giving the

Manufacture people a ‘zero-variation’ goal, we’ve implicitly told them to sub-optimise relative to the overall system.

Zero variation in this regard is akin to equally naïve targets like ‘zero tolerance’. When the designers upstream of the manufacture operation hear these kinds of phrase, they use it as license to design components with tighter and tighter tolerances. Because – ‘obviously’ tighter is better. Continue this thinking for more than a couple of years and what you end up with are systems that perform absolutely impeccably and absolutely consistently on day one of service operation. But then, as the aerospace industry rapidly found out when they started flying aircraft in desert conditions, where jet-engines are ingesting kilograms of airborne dust and sand, performance of those beautifully engineered ‘Swiss watch’ engines rapidly degrades. A new engine is not the same as an engine that has flown for 20 hours of desert conditions. Sand and other environmental contaminants, it turns out, have an uncanny knack of damaging high-speed rotating components. And so a one micron tolerance seal rapidly finds it has become a seal with 50 micron leaks.

By designing the ‘perfect’ solution – from the manufacturers zero-tolerance, zero-variation perspective – we’ve created something capable only of operating in perfect conditions. And the real world is anything but perfect. It is full of dust and sand, rain, snow and ice, leaves, pollen, insects and a million other ‘imperfections’.

Designing the ‘perfect’ solution for an imperfect world means doing the precise opposite of what ZVM and zero-tolerance aim at. Far better to let things move and vary because that’s exactly what the environment will cause anyway if we don’t. Far better to let the system move and shift to continually find its own optimum from moment to moment. Far better to allow the system to self-organise. That’s the way to resilient systems. Or, better yet, ones that are antifragile.

Here’s a simple example to illustrate the point. Car wheels. The automotive industry still thinks it is a good idea to tighten up tolerances and reduce manufacture variation in order to give drivers a smoother ride. Ditto the tyre manufacturers. Then, because they’re still not very good at it, every time we change a tyre, the garage uses an expensive – also accurately manufactured – wheel-balancing machine. Then the hammer small weights onto the appropriate part of the wheel rim to give the driver a beautifully balanced wheel. Balanced, that is, until the tyre starts to wear, or picks up bits of debris, or is subjected to a bad skid. Now the wheel is no longer balanced.

The whole balance problem could have been very easily solved by allowing the wheel to dynamically ‘balance-itself’. A feat that is very easily accomplished dropping a handful of tiny beads (or, better yet, ‘sand’) into the tyre when it is fitted to the wheel rim

Figure 2: Self-Balancing Car Wheel Beads

Now what happens is the beads ‘magically’ orient themselves to counteract any out-of-balance forces. The wheel remains as balanced on day 2000 as it was the first day the wheel was installed. No effort, no need for tight tolerances. Resilient not robust.

Pulling matters together, as ever, it seems we have a contradiction here. ZFM is both a good and a bad thing. We might map the contradiction to look something like this:

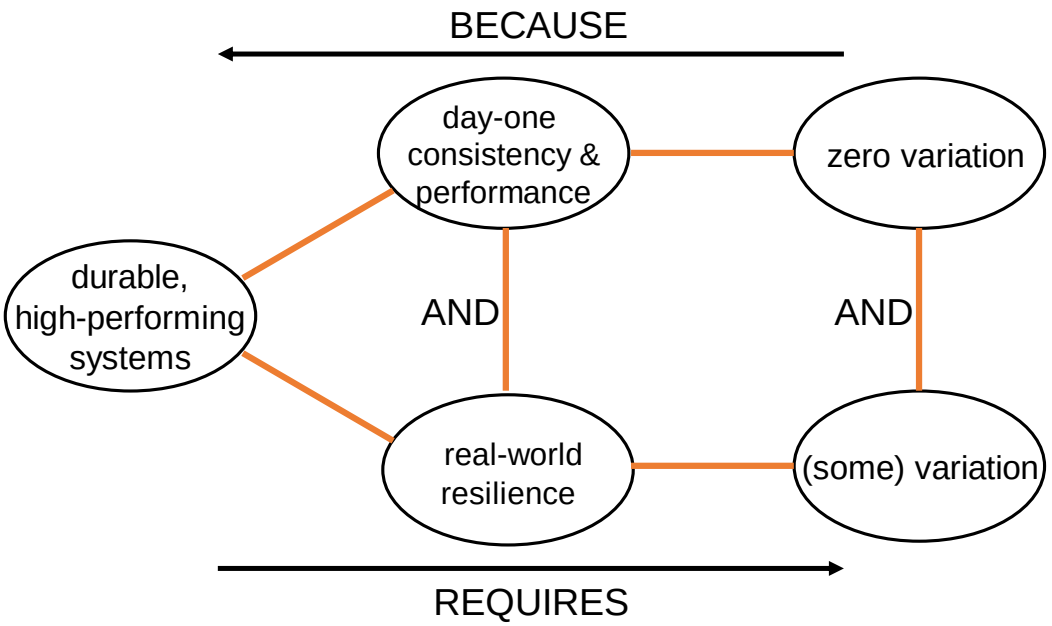


Figure 3: The Variation-Zero-Variation Contradiction

Once formulated, we also know that every contradiction becomes solvable. Looking at the variation-zero-variation physical contradiction, my first instincts are to say it is most readily solvable using a ‘separation on condition’ strategy: if the manufactured system will never encounter the real world, or will only encounter it for short periods of time, ZVM is probably a good idea (especially if we can achieve it for free – another contradiction). If, however, the system we’re designing is expected to operate for prolonged periods of time in the real world, a completely different design and manufacture strategy is called for. One in which we don’t let the Manufacture silo forget that optimizing their bit is very definitely making everyone else’s life, especially the reliability engineers, significantly worse.

Reference

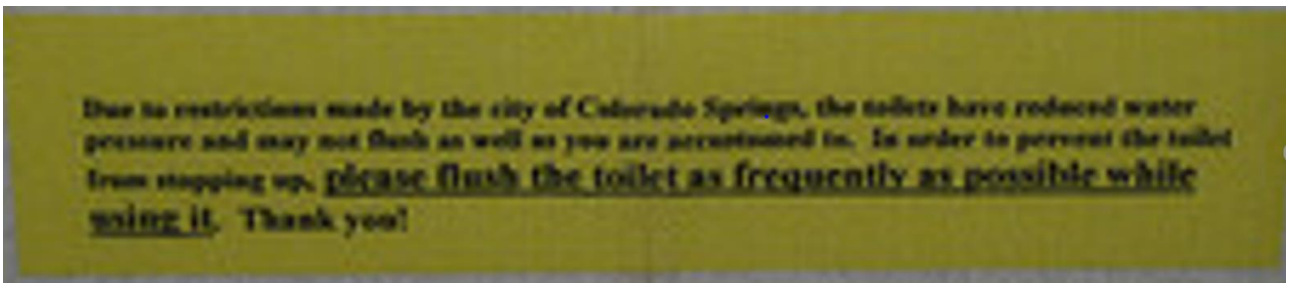
1) Boorla, S.M., Eifler, T., McMahon, C.A., Howard, T.J., ‘Product Robustness Philosophy - A Strategy Towards Zero Variation Manufacturing (ZVM)’, Management and Production Engineering Review, 9(2), 3-12, DOI: 10.24425/119520, 2018.

Definitely Not Funny – The Iron Law Of Unintended Consequences

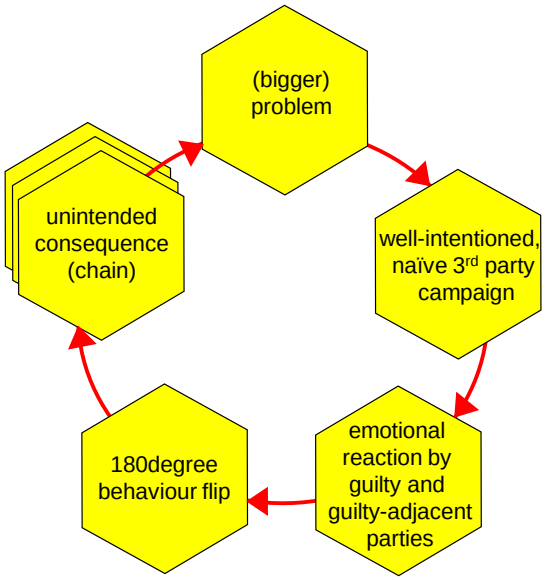
Not so long ago I proposed a new rule: No-one should be allowed to run for public office or work in a management position unless they've successfully passed a Complex Adaptive Systems 101 course.

If we don't understand complexity we don't understand that the relationships between the actions we take and the reactions they trigger can often be highly tenuous. Worse still, the more well intentioned an action is, the greater the likelihood that the reaction will be 180 degrees opposite to what was intended.

Take this water-saving idea from Colorado Springs:



The basic unintended consequence model looks something like this:



SYSTEM ATIC INNOVAT ION

If it wasn't so tragic it would be funny. Especially in light of the fact that it is often those acting as a proxy to the problem victims who trigger what can very easily turn into a horrible vicious cycle.

Here's a recent Bloomberg article relating to one of the unintended consequences of the highly admirable #MeToo campaign. Sexual harassment is a bad thing, but trying to solve the problem by calling it out is already doing nothing but exacerbating the problem. The vicious cycle hasn't been completed yet, but its easy to see how the first of the unintended consequences will quickly devolve into the second…

No more dinners with female colleagues. Don't sit next to them on flights. Book hotel rooms on different floors. Avoid one-on-one meetings.

In fact, as a wealth adviser put it, just hiring a woman these days is "an unknown risk." What if she took something he said the wrong way?

Across Wall Street, men are adopting controversial strategies for the #MeToo era and, in the process, making life even harder for women.

Call it the Pence Effect, after U.S. Vice President Mike Pence, who has said he avoids dining alone with any woman other than his wife. In finance, the overarching impact can be, in essence, gender segregation.

Interviews with more than 30 senior executives suggest many are spooked by #MeToo and struggling to cope. "It's creating a sense of walking on eggshells," said David Bahnsen, a former managing director at Morgan Stanley who's now an independent adviser overseeing more than $1.5 billion.

This is hardly a single-industry phenomenon, as men across the country check their behavior at work, to protect themselves in the face of what they consider unreasonable political correctness -- or to simply do the right thing. The upshot is forceful on Wall Street, where women are scarce in the upper ranks. The industry has also long nurtured a culture that keeps harassment complaints out of the courts and public eye, and has so far avoided a mega-scandal like the one that has engulfed Harvey Weinstein.

Now, more than a year into the #MeToo movement -- with its devastating revelations of harassment and abuse in Hollywood, Silicon Valley and beyond -- Wall Street risks becoming more of a boy's club, rather than less of one.

"Women are grasping for ideas on how to deal with it, because it is affecting our careers," said Karen Elinski, president of the Financial Women's Association and a senior vice president at Wells Fargo & Co. "It's a real loss."

There's a danger, too, for companies that fail to squash the isolating backlash and don't take steps to have top managers be open about the issue and make it safe for everyone to discuss it, said Stephen Zweig, an employment attorney with FordHarrison.

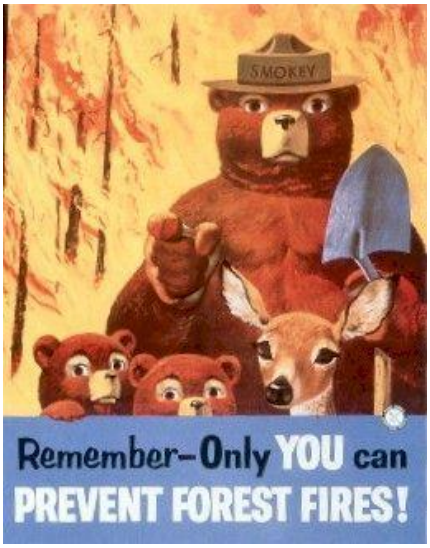
"If men avoid working or traveling with women alone, or stop mentoring women for fear of being accused of sexual harassment," he said, "those men are going to back out of a sexual harassment complaint and right into a sex discrimination complaint."

Other well-intentioned initiatives have already matured into societal problems that are now almost completely unsolvable. Think Sarah's Law. Prohibition Laws. Tightened bankruptcy laws. Gun buy-back laws. Incentives to kill snakes. Anti-pollution laws… I like the 1989 Mexico City one involving a policy called Hoy No Circula ("You Don't Drive Today"), which simply banned a certain percentage of the city's cars from driving each day. The way they did it was by license plate number - if yours ended in a 5 or a 6, then you weren't allowed to drive your car on a Monday, so you would have to carpool, take a cab, or bike your ass

to work. The next day, you could drive, but somebody else would have to walk, etc. Sounds great, except, apparently underestimating the lengths people will go to in order to not do as they're told, Hoy No Circula only restricted car use between 5 a.m. and 10 p.m., leaving drivers with a cool seven hours with which to make up for the day's lost pollution. Air pollution levels increased during the off hours, showing that people would rather work a 17-hour day than take the bus.

But those who wanted a more convenient way to get around the law simply bought a second car. The policy applied to cars, not people, and thus didn't restrict anyone from driving a different car with different plates on those "off" days. Not only did this increase the number of cars in Mexico City, but people usually opted to buy really cheap, shitty, hyper-polluting used cars as their backup, so they were polluting more on their off days than when they were allowed to drive their regular car.

I also quite like the Smokey The Bear forest fire prevention story from the US



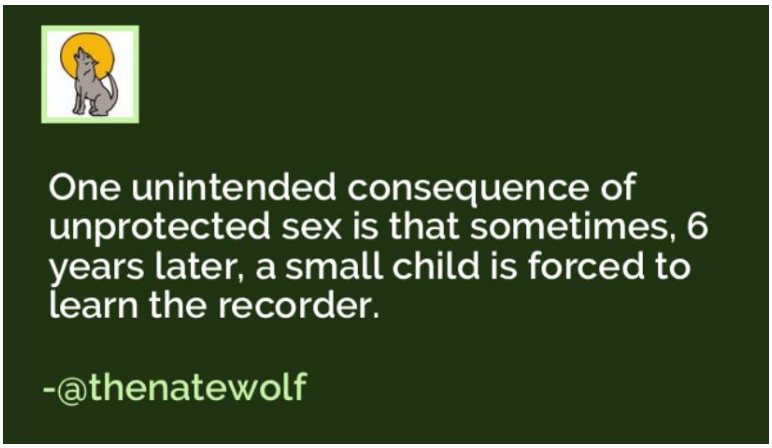
The Forest Service's Smokey campaign was very successful, but environmentally speaking, we know now it wasn't such a good idea. Beginning in the early 20th century, the federal government – principally the Forest Service, but also other agencies like eventually the BLM and the Bureau of Indian Affairs – committed themselves to an operational model that mandated full suppression of fires in national forestlands, wherever they occurred. Sounds like a good idea, right? Well, ecologically, it's not that simple. Many forest fires are started by humans, whether negligently, carelessly or deliberately, but some are also natural, such as from lightning strikes, and they are part of the ecological process of clearing out small brush and downed branches from the forest floor. Not all forest fires are bad. The government's tendency to treat them that way, however,

especially in the 1940s when Smokey debuted, meant that this brush built up in many forests.

When they burned, the intensity of the fires was often much greater than it would have been under natural conditions. This paradigm did not really begin to change until the 1970s, when the relatively new science of ecology began to take hold at policy levels, recognizing that the balances of forest ecosystems are more complex than they seemed. Unfortunately, we are still living with the results of the “pure suppression” model. In the past few decades, wildfires have grown progressively more catastrophic, in large part due to drought and climate change, but also because too few forests have been “managed” to reduce the underbrush fuels that can make fires much worse than they should be. Furthermore, as more people move to fire-prone areas, especially in the West, they bring with them an assumption that it is the federal government’s responsibility–not theirs and not their local communities’–to protect them from wildfires.

Ironically the “Only You” and Smokey campaigns obliquely reinforced this assumption. It’s your job, said Smokey, to prevent fires, but suppressing them once they start is someone else’s. The federal government can’t shoulder the financial burden alone, especially in the era of climate change.

Sometimes the string of unintended consequences can, like this forest-fire story be quite a long one. Here’s another multi-step, multi-year consequence chain:



Other times, the vicious loop cycle happens quite quickly. Like this one:


SUNDAY • July 8, 2012

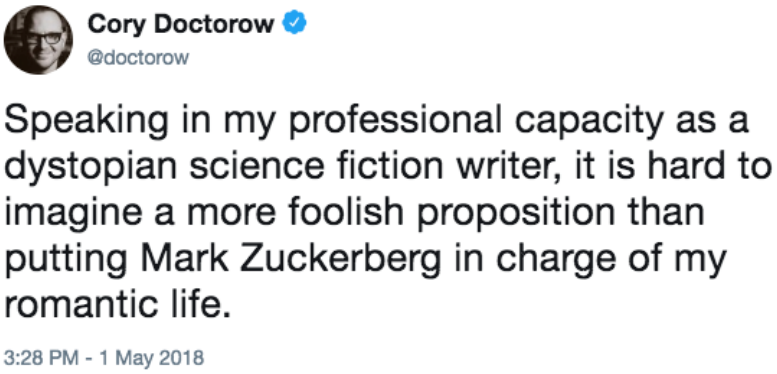
ENTERPRISE RECORD

Unintended consequences

Man sets house ablaze while killing spiders with propane blowtorch

This one is also likely to be fairly direct too. Albeit for different reasons:

SYSTEM ATIC INNOVAT ION



Finally, in a bid to avoid thinking about the impending relationship between Brexit and unintended consequences, here's a different example of the need for the Complex Adaptive Systems 101 rule:

in order to replace the use of coal in the UK, power stations are being refitted to burn wood chips. But the UK doesn't have enough forests to supply the wood chips, (biofuel) so…
…power companies in the UK are planning on purchasing timber in the United States to be converted to wood chips to be shipped across the Atlantic to burn in the previously coal-fired power plants.

Next stop, Electric Vehicle legislation, social media curbing legislation and cyber-security surveillance laws. If they don't knock all the dominoes over, nothing will. Happy New Year.

Patent of the Month – High Refractive Index Nanocomposite

A rare trip to Maryland for our patent of the month this month. US10,144,482 was granted to a trio of inventors at Pixelligent Technologies (pixelligent.com) on December 4. Here's what they have to say about the problem addressed by the invention:

An OLED device without light extraction scheme.

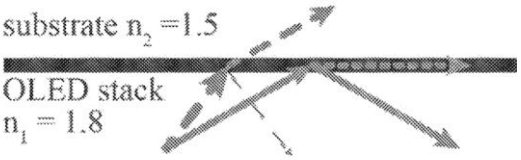


FIG. 1A

Internal light extraction with scatterers or surface texture, with all light being scattered.

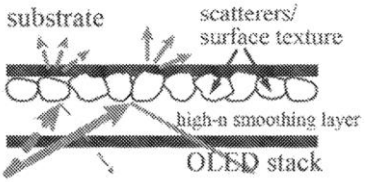


FIG. 1B

The invention, an ideal gradient-index layer with sparse light scatterers adjacent to the transparent electrode. The solid rays are refracted backward by the gradient-index profile, resulting in a much longer optical path and much higher scattering probability than the dashed rays, a more efficient mechanism compared to Fig 1.b.

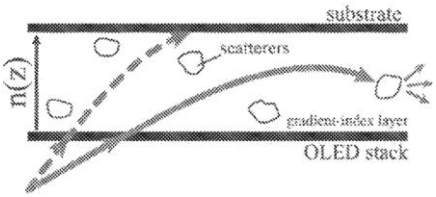


FIG. 1C

Polymeric coating materials described herein exhibit high optical transmittance in the visible spectrum. The materials of the present disclosure may be easily coated onto the surface of desired substrates via common coating processes, such as by spin coating, screen printing, dip, roll-to-roll, slot die, draw bar, or spray coating, for many electronic applications. The thickness of coatings described herein may range from tens of nanometers to millimeters, as may be required for specific applications. The materials of the present disclosure are unique in additionally providing a high refractive, high transparency film or coating or layer, as may be desirable in electronics applications where light coupling is important to the performance.

For example, in a traditional Organic Light Emitting Diode (OLED), only .about.30% of light generated is emitted to the environment, while the remaining light is generally lost in the device. A high percentage of this loss is due to the low refractive index (RI) of the encapsulation materials. A high refractive index high transparency organic coating, with a refractive index around 1.8 or higher, as may be produced with a material of the present disclosure, may dramatically enhance the efficacy of the OLED lighting and display devices including same. High refractive index

coatings of the present disclosure will also be advantageously incorporated in other devices, such as light emitting diode (LED) lighting, light emitting diode (LED) displays, touch screens, sensors, and solar cells.

The most prevalent light extraction scheme in current commercial OLED lighting is to roughen the surface of the substrate or to apply periodic structures on the substrate as external light extraction structures, such as the films provided by 3M. However, such external light extraction can only address the light loss at the glass/air interface and not the light lost at other interfaces, most notably at the ITO/glass interface, as shown in FIG. 1A. The light extraction efficiency of most state-of-the-art OLED lighting technology is only .about.40%, even for phosphorescent emitter where with nearly 100% internal quantum efficiency.

The root cause of the light extraction problem is the mismatch of the Refractive Indexes (RI) between where light is created in the device and where light is needed. The losses by Fresnel reflection and total internal reflection (TIR) at the interfaces in the device quickly add up, as illustrated in FIG. 1B.

IMPROVING PARAMETERS YOU HAVE SELECTED:

Illumination Intensity (23)

WORSENING PARAMETERS YOU HAVE SELECTED:

Compatibility/Connectivity (33)

SUGGESTED INVENTIVE PRINCIPLES:

32, 35, 1, 13, 6, 10

To recoup a larger portion of the light loss, an efficient OLED internal light extraction structure is critical, and it must be cost effective and compatible with existing OLED manufacturing processes to be commercially successful. One popular scheme is to introduce light scatters or surface texture at the interface between the OLED layer, more specifically the ITO electrode, and the substrate, as shown in FIG. 1B. In order to generate sufficient light scattering events over a short distance, the concentration of the light scatters has to be large at the interface, which scatters light indiscriminately, resulting in the unnecessary scattering of the light that is within the cone of acceptance. Also, the scatterers at the interface lead to poor surface quality that requires an application of a high-index smoothing layer to prevent current leakage and defective devices. This extra smoothing layer increases the processing complexity.

IMPROVING PARAMETERS YOU HAVE SELECTED:

Illumination Intensity (23)

WORSENING PARAMETERS YOU HAVE SELECTED:

Manufacturability (41) and System Complexity (45)

SUGGESTED INVENTIVE PRINCIPLES:

35, 5, 28, 15, 20, 13, 2, 6, 33, 25, 16, 17, 26, 4

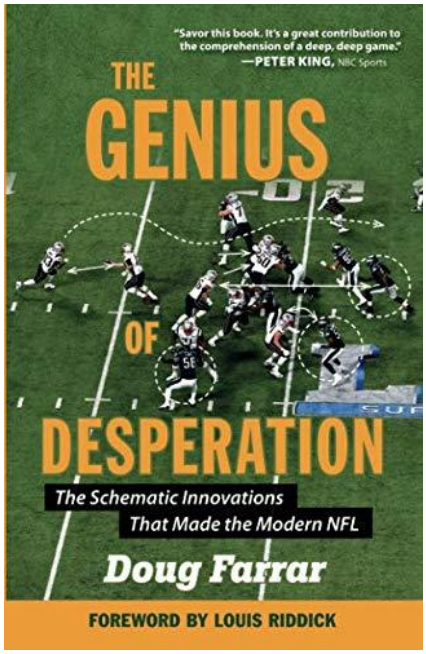
And here's how the invention solves the problem:

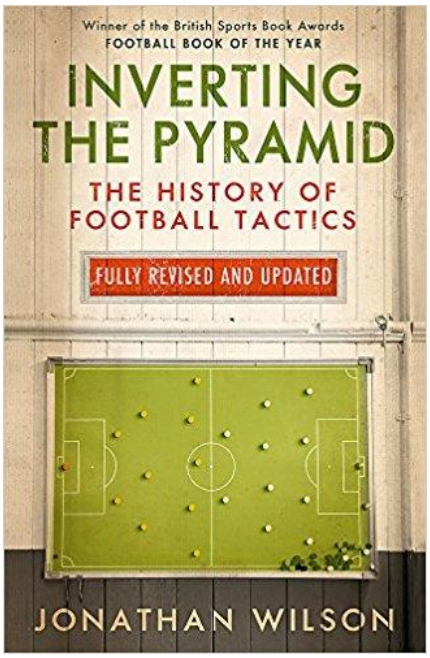
SYSTEM ATIC INNOVAT ION

The present invention comprises an innovative internal light extraction scheme based on a nanocomposite gradient-index [Principle 3, Local Quality] *layer sparsely* [Principle 2, Taking Out] *embedded with light scattering centers, a UV curable coating formulation consisting of ZrO.sub.2* [Principle 35, Parameter Changes] *nanocrystals dispersed into an acrylic polymer that is applied with slot die coating, where the gradient-index is achieved by varying the concentration of nanocrystals. Incorporating a gradient-index offers two main benefits: First, a gradient-refractive index profile (or a discreet approximation, i.e. thin layers with small index changes) can significantly suppress Fresnel reflection; Second, only a low concentration of light scatterers is needed. Because in a gradient-index layer, light rays that travel outside the acceptance cone are bent backward, the optical paths of these rays are significantly longer compared with the rays that transmit within the cone of acceptance, as shown in FIG. 1C. By introducing a small concentration of light scatterers inside the gradient-index layer, the present invention allows the light that requires extraction to be more likely to be scattered, than the light that would escape on its own.*

This is absolutely our favourite kind of invention: solve the problem by removing things from the system, and using what you decide to keep far more intelligently. Borderline genius. Quite literally, on both counts.

Best of the Month – The Genius Of Desperation/Inverting The Pyramid





Something of an either/or choice this month as far as reading recommendations go: football or football. American or Association. While the specifics might be different, the themes are both the same: an author with a steely determination to get to the bottom of strategic and tactical shifts that caused football teams to be successful. In other words, both books are about step-change innovation. And – surprise, surprise – the heart of those innovations turns out to be some form of crisis. i.e. contradiction. The title of Doug Farrar's book is the most explicit, 'The Genius of Desperation'. His compelling hypothesis is that it is pretty much *only* when NFL teams have found themselves in crisis (a quarterback that can't throw long balls any more following injury, a weak defence) that coaches have been forced to develop innovative new strategies to overcome the crisis problem.

Farrar's book was published earlier this year, but already looks like becoming a classic history of tactics. I can't claim to be an expert on NFL and so I have to admit that some of the terminology used goes a little over my head. That said, I understand the sport well enough to see that the enormous amount of science involved in the sport these days (the amount of data that is gathered on each player during and beyond each game is incredible) reveals a very typical picture. One that is highly analogous to continuous improvement and innovation initiatives inside business enterprises. The only real difference is that because the on-field dynamics of a game are so fast-moving, the optimization process (climbing the s-curve) happens that much faster than things are able to change in the corporate world. Sport is the safe version of an evolutionary arms race: the moment one opponent discovers a new way of doing things, the other opponent has to rapidly develop a counter-solution. When everyone ends up using the same data, the s-curve gets climbed and as the law of iminishing returns kicks in it becomes increasingly likely that the two-teams simply neutralize one another. Until – 'the genius of desperation' – one team successfully jumps to a new s-curve… which, in true arms race fashion, then causes the other teams to respond with their own jump. An attacking play s-curve jump necessitates a defensive play s-curve jump; a defensive play s-curve jump necessitates an attacking play s-curve jump. What Farrar offers up is a detailed analysis of these desperation-triggered s-curve jumps. He doesn't understand s-curves or contradictions or

TRIZ, but what The Genius of Desperation offers up is a string of terrific contradiction-emerges-contradiction-gets-solved journeys. We already know from a first reading of the book that these s-curve jumping solutions match very closely to the TRIZ Inventive Principles… don't be surprised, then, if sometime in the not too distant future we end up writing a more detailed reverse-engineering of Farrar's story, taking each contradiction and each solution that has occurred over the course of NFL's history and mapping it to the TRIZ tools. Who knows, we might bget a whole new Contradiction Matrix out of the analysis.

The same thing absolutely applies to Jonathan Wilson's classic (we know this one is a classic just by looking at it's global spread since the 2008 first edition). It offers us a jump-by-jump look at the discontinuous evolution of the real 'football'.

"Inverting the Pyramid" walks readers through the evolution of tactics within the world of football and describes the societal surroundings in which they took place. Tactics within the game didn't just develop through battles (arms-race contradictions) on the pitch (though that is largely a driving force). They developed in ways that allowed individual cultures to (different kind of contradiction) keep their identities while remaining competitive.

The book starts in England in the 19th century, and quickly progresses through the stylistic disagreements between the Scottish and English over the importance of individual talent and possession. From there, it follows a simple path to Central Europe. The middle of the book is largely spent bouncing back and forth between Europe and South America, as the two continents continued to develop comparable ideas with subtle differences that made the two games differ greatly. The book ends with a return to Europe, and the progressions made from the late-1970s until the early 2010s.

Wilson does a fantastic job of walking readers through the differing terms, describing their origins both tactically and linguistically. He explains the origins of the libero in the Italian defense as well as the subtle differences between the trequartista in Italy and the enganche in Argentina. He goes in depth on the difference between the traditional 4-3-3, the 4-3-3 played in Argentina, the 4-3-3 as played by Michels, Cruyff, and Pep, and the 4-3-3 played by Rijkaard. Wilson outlines phenomenally the tactics that allowed Brazil's free-flowing attack to tick in the 1970 World Cup, and how it differs from the free-flowing attack of Total Football. He describes why tactics blossomed in central Europe in the 1920s and 1930s, why Italy plays a very physical and defensive style, and how Total Football completely reshaped FC Barcelona.

Overall, perhaps because I've grown up with football, I really enjoyed the book. It moves along at a gallop, but it also does a fantastic job of developing a deep understanding of the game. It combines the intellectual side of the sport with the entertainment side, and helps give the reader a better insight into why some teams are better than others – even when the talent isn't equal. The book isn't perfect, by any means (449 pages, for a start, makes it something of a long haul even if it does flow effortlessly), and there are certainly pieces of literature that delve deeper into the tactical side of the sport, but this book is an incredibly valuable piece regardless of where you are in your knowledge of the tactical game. It also, like Farrar, offers up a very TRIZ-like bringing together of innovation first-principles. And with that in mind, even if you have zero interest in football or football, if you like TRIZ or innovation, either book might just become your favourite new thing. Arms-races always deliver an environment for rapid innovation. Safe arms-races between two competing teams deliver the same. Only faster. Biologists often look to study nature using fruit-flies because they breed so quickly. Competitive sports, by analogy, might just be the fruit-flies of the innovation world.

Wow In Music - Horses

Pipping the Ramones' first album to the post by five months, Horses is generally considered not just one of the most startling debuts in rock history but the spark that ignited the punk explosion.

Exactly forty-three years ago this month, on December 13, Arista Records released Patti Smith's debut album. The historical importance of Horses is inarguable, above and beyond any particular aesthetic considerations. It introduced, fully formed, a daring new mystic voice in popular music. It referenced a classic persona, that of the androgynous poet/rocker, and gave it an exciting twist: the poet/rocker in question was a (Principle 13) woman. And for listeners outside of New York, it was the first real full-length hint of the artistic ferment taking place in the mid-'70s at the juncture of Bowery and Bleecker.

The word "punk" would later be attached to everything CBGB-related, but Horses is more punk in its attitude than in its sound. It takes a cabaret approach to rock, and by cabaret, the album is more Brecht/Weill rather than the Sweeney Sisters. Richard Sohl's graceful keyboard work drives the arrangements more than Lenny Kaye's scratchy guitar (Principle 37), and although the band can work up a good head of steam, it tends to do so in a knowingly theatrical way. This music has a deeper affinity to Van Morrison lapsing into animal noises on "Listen to the Lion" than to the primal power of the Ramones.

While we're on the subject of animal noises, it must be acknowledged that Horses is not always a pleasant listening experience (Principle 22). Smith didn't intend it to be. Over the course of its 44 minutes, she (Principle 38) bleats like a goat, yelps like a cat whose tail has been stepped on, howls like an abandoned toddler and pounds her chest while she sings to give her voice a guttural gulp. All for what? Like a shaman (a word and a concept she loves), she's always reaching for the transcendent, trying to slip past the borders of her own self, enter the spirits of others, and meld with the mysterious force that binds us all together. She doesn't always attain this transcendence, but she knows where she can find it: in rock and roll.

That is the abiding message of "Gloria" and "Land," the garage-recitative suites that are Horses' two centerpieces. The message is conveyed more through the music's overall

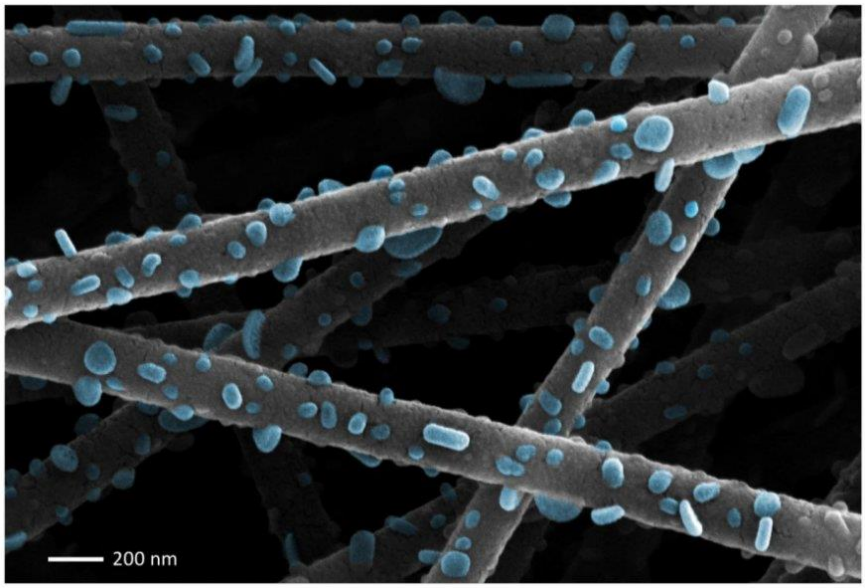
mood, the (Principle 19) swells and surges of the band, and the sound of Smith's voice—(Principle 37) harsh edge, yearning center—than it is through her words (which, truth be told, verge on (Principle 2) gibberish at times, especially during "Land"). And that message further confirms that this album could only have been made by people who were young and starstruck in the '60s.

It's true, you don't have to be familiar with "Gloria" as rendered by Them (or any number of others) or "Land of 1,000 Dances" as rendered by Wilson Pickett (ditto) to appreciate what's going on here. But it sure helps a lot if you are, and if you subscribe to the notion that three chords and the truth are really all that matters.

These holy, orgiastic moments are necessary to (Principle 8) counterbalance the rest of the disc, much of which - "Redondo Beach," "Birdland," "Break It Up," "Elegie" - is fixated on death. One curious irony about Horses is that an album so closely associated with the beginning of something (punk) is itself so concerned with endings. "I think it's sad, it's much too bad, that our friends can't be with us today," is how closing song Elegie ends. When Smith sang those words, the foremost person in her mind was Jimi Hendrix. Horses was recorded, after all, in the studio he'd built, Electric Lady on 8th Street; Smith had met him there at the studio's opening party, only weeks before he died. But she was also singing for other departed counterculture heroes like Jim Morrison, Janis Joplin and Brian Jones. She and her baby boomer peers felt, with some justification, that their lives had already been permanently altered by loss.

Those closing lines, however, for me still pale into insignificance relative to the album's iconic opening line. "Jesus died for somebody's sins but not mine," is about as good as it gets in terms of an announcement of your arrival. One might go so far as to say that Smith's entire career was made in these first few seconds. A Ground-Zero, Principle 13 twist that sparked a quite literal musical revolution.

Investments – Cheap Nanoparticles



An inexpensive way to make products incorporating nanoparticles – such as high-performance energy devices or sophisticated diagnostic tests – has been developed by researchers. The process could speed the commercial development of devices, materials and technologies that exploit the physical properties of nanoparticles, which are thousands of times thinner than a human hair.

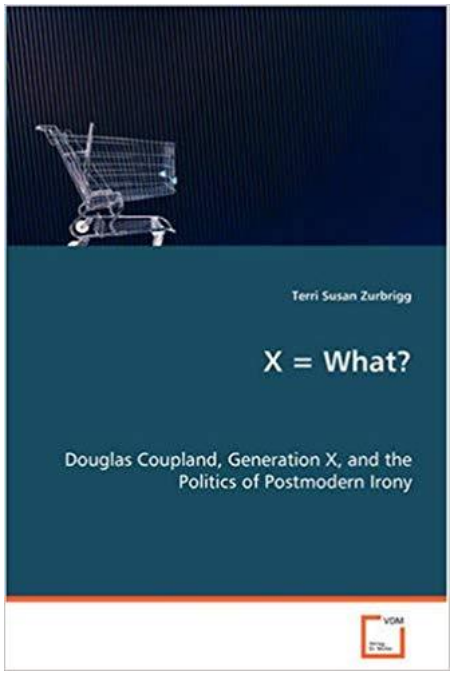
The particles' small size means they behave differently compared with conventional materials, and their unusual properties are inspiring research towards new applications. Engineers demonstrated their manufacturing technique, known as electrospinning, by building a fuel cell – a device that converts fuels into electrical power without combustion. Their device was produced featuring strands of nanoscale fibres incorporating nanoparticles on the surface. It offers a high contact area between the fuel cell components and the oxygen in the air, making it more efficient.

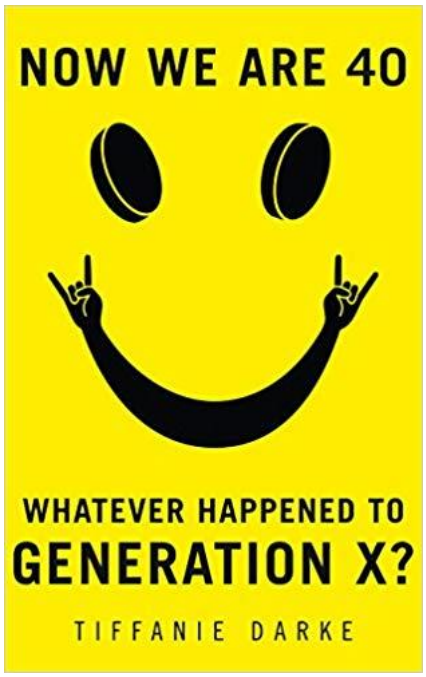
Researchers at the University of Edinburgh and California Institute of Technology built their fuel cell using a nozzle-free electrospinning device – a rotating drum in a bath of liquid under high voltage and temperature (three fields, no less). Nanofibres are produced from the liquid on the surface of the drum, which are spun onto an adjacent hot surface. As the fibres cool to form a fuel cell component, nanocrystals emerge on their surface, creating a large surface area.

Tests showed the nanofibre fuel cell performed better than conventional components. Such devices are very difficult to manufacture by other techniques, researchers say. The study, published in Nature Communications, was funded by the US Department of Energy. Dr Norbert Radacsi, of the University of Edinburgh's School of Engineering, who led the study, said: "Our approach of electrospinning offers a quick and inexpensive way to form nanomaterials with high surface area. This could lead to products with improved performance, such as fuel cells, on an industrial scale."

Read more:
Norbert Radacsi, Fernando Diaz Campos, Calum R. I. Chisholm, Konstantinos P. Giapis. Spontaneous formation of nanoparticles on electrospun nanofibres. Nature Communications, 2018; 9 (1) DOI: 10.1038/s41467-018-07243-5

Generational Cycles – Irony





I'm a sucker for Generation Cycles books. Part attempt to find evidence to (one day!) negate the Strauss & Howe model, part smug self-satisfaction. The most recent venture was Tiffanie Darke's 'Now We Are 40' romp. A great example of extrapolating a theory from half a dozen data-points. Which is to say that as research it makes for a great ashtray. It was, however, a terrifically readable romp, and, if you already knew the Strauss & Howe model, you could see how Ms Darke did an amazing job of confirming everything they said without ever having heard of them. To that extent, it makes for a useful – independent – confirmation of Strauss & Howes archetypal descriptions of Nomad generations. Reflecting on the book afterwards, I might go a tad further and say that Darke's book brought a shining spotlight on a pair of attributes that are so Generation X that they've become kind of invisible: Nomads are driven by cool and irony.

Recently, my sister and I were gently teasing our father about how cool he was looking in his argyle-patterned cardigan. He said to our mother, "I never know with these two if they're being serious or not."

And a weird realisation struck me: a lot of the time, neither do I.

This is the curse, gift and defining characteristic of Generation X: irony. My dad's generation, and those before him, were sincere: they meant what they said and said what they meant.

But by the time Generation X started being born, in the mid 60s and especially into the 1970s, some detached, too-cool Left Bank intellectual had taken a break from his doctorate in semiotics to invent postmodernism, and we were doomed to a world of irony.

Nomads grew up with it and in it. Nomads swam in its invisible currents, like a school of bizarre fish wearing stylishly outmoded spectacles and T-shirts of long-forgotten cartoons. Irony was Nomad amniotic fluid, the mother's milk, the Knight Rider lunchbox (that many Nomads still keep, tragically, as a totem of nostalgia – another crucial strand of Gen X DNA).

Because of ever-more self-reflexive culture and generational mores, Nomads tend to see everything through the prism of postmodernism. Nomads like – or pretend to like, and to them it's virtually the same thing – big-hair metal, daytime soaps, playing pop music's greatest parlour game ‘spot the genuine irony in (fellow-Nomad) Alanis Morissette’s song, 'Ironic', Diff'rent Strokes reruns, jokes that are funny because they're deliberately unfunny, bad acting, bad special effects, bad anything so long as it's bad enough.

The Generation X uniform is the ironic T-shirt; even better if the slogan across the chest adds an extra layer of self-reference, a sartorial wink and nod to the audience of our peers: "You are not reading this T-shirt." Arf, arf.

Since before GenX existed, irony has been seeping through the culture, percolating down like the strong coffee we prefer to alcohol because booze is so lame and mainstream – to the extent that, by now, we're never entirely sure when we mean something or not.

As usual, The Simpsons capture it best. Two slackers at Hullabalooza (a pitch-perfect allusion to Lollapalooza, travelling Mecca of Gen X's devotion). One says: "Here comes that cannonball guy. He's cool." His friend asks, "Are you being sarcastic, dude?", and gets the forlorn response: "I don't even know anymore."

Did I really think my pop's cardigan was nice? Dude, I don't even know anymore.

My parents don't get this; they literally wouldn't understand what's funny about something that you know, absolutely, isn't funny. Generation gap? It's more like a whole different species.

But it gets worse: we're sincere in our insincerity, thus confusing the matter to proportions so Byzantine it couldn't be teased out by an intellectual tag-team of Steven Hawking and King Solomon.

I'll enjoy Steven Seagal's Kill Fist of Death Punch IV as part of some knowing, ironic joke to myself – I realise it's rubbish, and that's the point – but at the same time part of me will genuinely enjoy it. We'll mock someone for trying to save the world but we truly want them to save the world.

Everything is a pseudo-apathetic pose, a wry jibe, for Generation X; everything we say and do is lacquered with the bitter patina of sarcasm. We're ironic and infantile and don't take anything seriously, and yet – contradiction of contradictions – we take everything seriously.

We're as glum, idealistic and sincere as you could get – sometimes to extremes. The Gernation X godhead is Kurt Cobain, who in interviews displayed a sardonic playfulness and mocked his image as a doomy depressive, but ultimately killed himself because the world was inauthentic.

All of which is very disorientating when you're trying to work out if you really meant that compliment about your father's cardigan. Like, I did mean it. But I didn't. But I did and didn't at the same time.

Not that it matters, anyway. Dude, I'm being sarcastic. I probably don't mean any of this. Even though I do. Maybe. If you follow me.

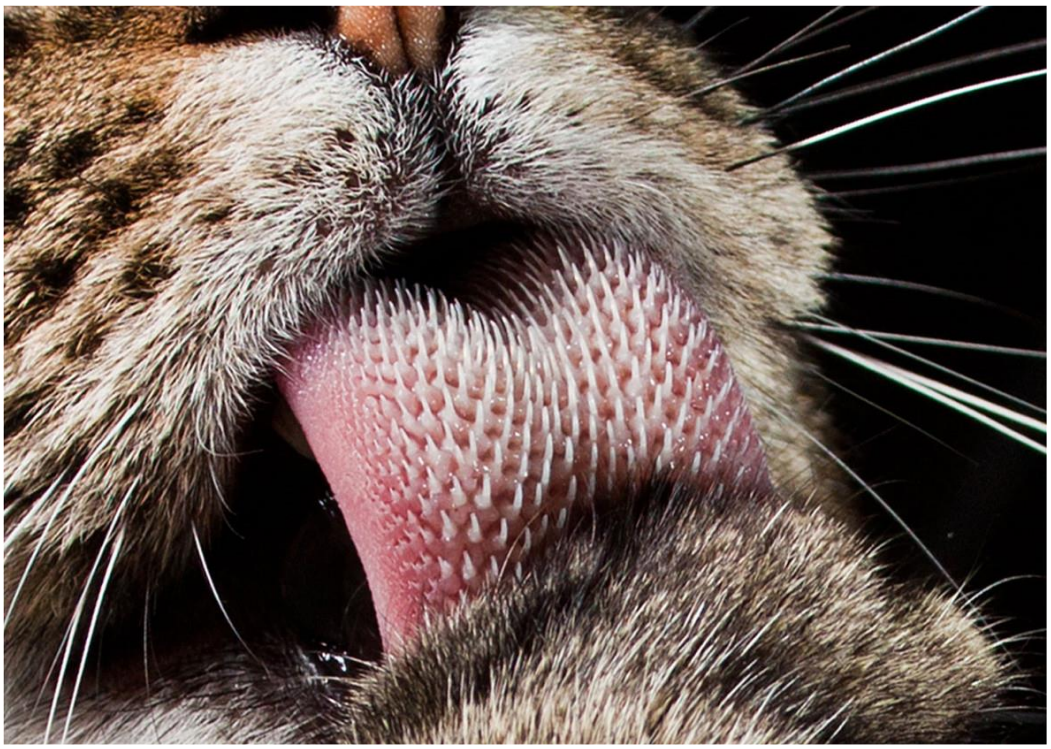
Demographics are destiny. Nomads grew up in the world and mind of the baby-boomers simply because there were so many of them. They were the biggest, easiest, most free-spending market the planet had ever known. What they wanted filled the shelves and what

fills the shelves is our history. They wanted to dance so we had rock ‘n’ roll. They wanted to open their minds so we had LSD. They did not want to go to war so that was it for the draft. We will grow old in the world and mind of the Millennials because there are even more of them. Because they don’t know what they want, the culture will be scrambled and the screens a never-ending scroll. They are not literally the children of the baby-boomers but might as well be—because here you have two vast generations, linking arms over Nomad heads, akin in the certainty that what they want they will have, and that what they have is right and good

The members of the in-between generation have moved through life squeezed fore and aft, with these tremendous populations pressing on either side, demanding we grow up and move away, or grow old and die—get out, delete your account, kill yourself. But it’s become clear to me that if the West has any chance of survival, of carrying its traditions deep into the 21st century, it will in no small part depend on members of Generation X, the last generation schooled in the old (first principles) manner, the last generation that know how to fold a newspaper, take a joke, and listen to a dirty story without losing their minds.

Though much derided, members of my generation turn out to be something like Humphrey Bogart in Casablanca—we’ve seen everything and grown tired of history and all the fighting and so have opened our own little joint at the edge of the desert, the last outpost in a world gone mad, the last light in the last saloon on the darkest night of the year. It’s not those who stormed the beaches and won the war, nor the hula-hooped millions who followed, nor what we have coming out of the colleges now—it’s Generation X that will be called the greatest. Now, the only thing you need to do is work out if I’m saying that ironically. Or not.

Biology – Cat Tongue



Cats love to groom themselves almost as much as they love to sleep, spending up to one-quarter of their waking hours cleaning their fur.

The secret to their self-cleaning success? The spines on their tongues are curved and hollow-tipped, according to a paper published this month in the journal PNAS. These tiny spines, called papillae, can transfer large amounts of saliva from mouth to fur, which not only cleanses Fluffy down to her skin but also lowers her body temperature as the saliva evaporates.

“A cat tongue works like a very smart comb,” says David Hu, a bioengineer at Georgia Tech and senior author of the new paper.

The results don’t just provide insight into how one of the world’s most popular pets stays clean. They’ve also inspired a new type of brush, called the TIGR (the Tongue-Inspired Grooming) brush. Studded with small, curved flexible spines just like those on a cat’s tongue, the TIGR prototype readily removes loose hair or fur from humans and felines alike but can be cleaned with the simple swipe of a finger. It may even possibly make cats less allergenic by removing excess dander, Hu says.

The researchers found that these scoop-shaped papillae are what allow cats to get saliva right down to their skin, which could inspire new approaches to cleaning and depositing fluids on all kinds of hairy, furry, and fuzzy surfaces. “Transporting liquids is a problem for animals and engineers,” says Sunghwan “Sunny” Jung, a bioengineer at Cornell University who was not involved in the research. “This paper shows that scientists can use the physics of basic animal behavior to answer fundamental questions.”

Hu’s PhD student, Alexis Noel, first became interested in cat grooming after watching her cat’s tongue repeatedly get snagged as it licked a microfiber blanket. Noel had seen her

cat licking itself plenty of times before, but as she watched it try to groom a fluffy blanket, she began to think about the process with fresh eyes.

The scoop-shaped papillae cover a cat's tongue and give it its sandpapery texture. It was these spines that got tangled in Noel's blanket. Noel wanted to understand why these papillae were so good at getting knots out of fur (and blankets). A quick skim of the research literature revealed that scientists had paid almost no attention to the biomechanics of cat grooming. Hu and Noel decided to change this. First, though, they would need cat tongues. Obtaining samples from deceased domestic cats was straightforward. Getting the tongues of wild cats, not so much.
"There aren't a lot of tongues just sitting around," he says.

After hassling zoos and animal reserves for months, they finally had enough samples. With tongues from six cat species—domestic cat, bobcat, cougar, snow leopard, tiger, and lion—Noel and Hu got a closer look at the papillae, zooming in with a micro-CT scanner. A 1982 paper reported that cat papillae had the shape of a hollow cone, but newer technology used by the Georgia Tech researchers revealed that the spines actually curved backwards towards the throat.

The difference sounds subtle, but it's not, Hu says. The curved shape of the papillae allows it to wick up water on contact, using surface tension—something that a hollow cone couldn't do.

"At this small scale, these differences really matter," Hu says.

Although each papilla may only be able to wick a fraction of a water droplet (4.1 microliters, to be precise), over the course of a day, the tongue of a domestic cat transfers an average of 48ml to its fur, about a fifth of a cup of water.

The researchers discovered that papillae's orientation wasn't fixed. High-speed videos of three short-haired domestic cats grooming showed that the papillae rotate as the cat's tongue encountered knots in its fur. This rotation let the spike probe even deeper into the fuzzy snarl and ultimately work it loose.

This flexibility, Hu says, is the key to what allows such relatively short spikes to clean not only the longer, sparser outer layer of fur but also the thick, down-like undercoat next to

the skin. The researchers' measurements revealed that even relatively light pressure from the tongue during grooming allowed all the species of cat to clean themselves down to the skin. The one exception? A Persian cat, a domestic breed that needs to be brushed daily to prevent mats from forming.

Understanding how cats stay clean was one thing, but as an engineer, Hu wanted to go further. When his kids got lice, Hu spent hours searching the pharmacy for the right brush to remove the nits, and then combing through their hair to remove every last trace of the lice. A quick Internet search revealed that combs hadn't changed much in tens of thousands of years. Hu's work with Noel made the pair think that perhaps the cat tongue could inspire something better.

"Looking for new materials by studying how cats groom is very cool—it shows you don't have to go deep into the forest to find something useful," says Sylvain Deville, an engineer at the French National Center for Scientific Research, who wasn't involved in the research. Using a silicone-based polymer, the pair 3D-printed a small, flexible brush about the size of two fingers held side-by-side. The spines on the brush were simply a scaled-up version of cat papillae. When Noel and Hu compared how well the TIGR and a human hairbrush could remove knots from a pelt of faux nylon fur, the TIGR removed more knots with less force than a standard brush. Noel could also remove the loose fur from the brush with the simple swipe of a finger, as opposed to painstakingly picking the hair out with tweezers.

It could also mean a better brush for cats, some of whom despise existing brushes currently on the market. The softness and flexibility of the TIGR may provide something closer to the cat's own grooming experience that's more tolerable for them—and their owners.

From a contradiction-solving perspective, the cat tongue offers up a master-class. Putting aside the fact that it also has a whole bunch of other functions to perform besides grooming, the grooming function alone should be full of compromises: we want fur to be unknotted (so the tongue needs to grip it hard), but we don't want the fur to stick to the tongue (so the tongue needs to *not* grip it hard); we want to penetrate right down to the skin but we don't want papillae to be long; we want to pick up fluid and also deposit fluid; we want to groom the fur in one direction, but untangling knots requires movement in multiple directions. Here's how we might start to contain some of that complexity in the Contradiction Matrix:

IMPROVING PARAMETERS YOU HAVE SELECTED:

Trainability/Operability/Controllability (34)

WORSENING PARAMETERS YOU HAVE SELECTED:

Length/Angle of Moving Object (3) and Amount of Substance (10)

SUGGESTED INVENTIVE PRINCIPLES:

17, 13, 1, 12, 4, 35, 3, 14, 15, 2

The results of which seem to make a pretty good instruction-set for the solution evolved by the cat:

Principle 1, Segmentation – segment the surface of the tongue into lots of papillae
Principle 3, Local Quality – different papillae are different sizes at different positions on the tongue
Principle 4, Asymmetry – the papillae use multiple dimensions of asymmetry, and also face ‘backwards’ towards the throat so as to achieve stickiness in one direction and ‘not-sticky’ in the other
Principle 14, Curvature – the scoop-shape of the papillae, and the papillae rotate as they encounter knots
Principle 15, Dynamics – the papillae move and have a varying orientation
Principle 17, Another Dimension – the papillae stick up from the surface of the tongue

All in all, from an evolutionary perspective, while every biologist usually declares the brain or eyes as the most amazing outcomes of the evolution process, I’d like to add the cat’s tongue to the list of candidates for the most sophisticated system on the planet. I think I might even be able to put up with my cat’s habit of licking my nose from now on. It’s not annoying, it’s evolutionary genius.

Short Thort

“The music is not in the notes, but in the silence between.”
Wolfgang Amadeus Mozart

“There are all kinds of silences and each of them means a different thing. There is the silence that comes with morning in a forest, and this is different from the silence of a sleeping city. There is silence after a rainstorm, and before a rainstorm, and these are not the same. There is the silence of emptiness, the silence of fear, the silence of doubt. There is a certain silence that can emanate from a lifeless object as from a chair lately used, or from a piano with old dust upon its keys, or from anything that has answered to the need of a man, for pleasure or for work. This kind of silence can speak. Its voice may be melancholy, but it is not always so; for the chair may have been left by a laughing child or the last notes of the piano may have been raucous and gay. Whatever the mood or the circumstance, the essence of its quality may linger in the silence that follows. It is a soundless echo.”
Beryl Markham, West with the Night

“Experience teaches us that silence terrifies people the most.”
Bob Dylan

News

Nottingham Business School

Kobus will be presenting at the Systematic Innovation Seminar being convened by the IEEE at the Nottingham Business School. The event takes place on 23 January. More details: https://www.eventbrite.co.uk/e/systematic-innovation-seminar-tickets-52933908746

Cardiff University

Darrell will be speaking at an InsureTech executive breakfast at the University in mid-February. With a following wind, the session will be followed up by a one-day workshop in April. More details on the website.

Mexico

It's been a long time, but we finally get to go back to Mexico in 2019. The details are still being worked out, but currently looking like two weeks' worth of conferences and workshops in the first half of October. If any of our Mexican readers would like to organize internal workshops or projects, please get in touch with Darrell.

Break The Patent Stranglehold

Eagle-eyed followers may have noticed the low-key launch of our initiative to clean-up the dysfunctional world of intellectual property. A system that was set up to promote innovation now does the precise opposite. We love innovation and don't like anything that makes life more difficult than it ought to be. If you'd like to join us on the journey, you might like to check out breakthepatentstranglehold.com, and especially the 5 minute video.

Online MSc

2018 turned into a pretty tough one from an academic perspective. We were supposed to launch a Systematic Innovation MSc at the University of Buckingham back in April. For various reasons, we had to re-think how the programme worked. Just-in-Time learning, securing academic credit for delivering real world projects, distance learning, interactive video content, students that just wish to get accreditation for learning TRIZ/SI. It now looks like we're launching the evolved programme in April. April 2019. Expect to see the new website soon.

New Projects

This month's new projects from around the Network:

Housing – Innovation Project
Mining – SI Certification Workshops
Transport – Innovation Coaching
Agriculture – Concept Design Study
Retail – SI Certification Workshops
Construction – Innovation Strategy Project
Construction – Design/Make Project

Happy New Year

We wish all of our readers a happy and meaningful 2019 and hope that you'll find the time to stay with us for the next twelve months… from our side, we can promise a whole load of new things to keep the TRIZ/SI story moving forward.

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