

# Systematic Innovation



**e-zine**

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# Rethinking The 'Robust Design' Trend

It's not often these days that we get to add a new stage to one of the Trends Of Evolution. It's even rarer that we find ourselves in the position of needing to re-name one of the Trends. Both of those things happen this month. The trend in question being the one we've known as 'Robust Design' since it found its way into the first edition of the Hands-On Systematic Innovation technical edition. It tends to be one of the less frequently used Trends, but that shouldn't take away anything from its overall importance in the greater scheme of things. It's probably the only Trend, in fact, that is likely going to merit a whole book to itself. If we ever get the chance to write it. Simple as the Robust Design Trend might appear, the deeper we dig, the more it has to tell us about understanding and solving reliability related problems as well as helping designers to design more 'robust' systems.

Except, we know see the language has changed when it comes to what we mean by 'robust'. When we first identified the Trend – back in the 1990s in the aerospace industry – creating a solution that was 'robust' was seen as the epitome of design. Now the way the world understands the term 'robust', we know it means that the solution is able to withstand considerable trauma before it fails, but, when the level of trauma exceeds a given threshold, the system tends to fail catastrophically. Far better, the robust-design community learned, was to design a system to be 'resilient'. Which means a solution that is able to adapt to trauma without failing.

Then along came Nassim Nicholas Taleb to give the world the word 'AntiFragile'. AntiFragile being yet another step beyond 'resilient' in that a system that is AntiFragile is not only able to adapt to trauma, but actually becomes stronger as a result. The more stress an AntiFragile system is put under, the stronger it becomes. Like a mythical Hydra. Cut off one of the serpent's heads and it grows two more. It was the image Taleb used continuously in the book to offer up an illustrative example of what AntiFragile was about.

There's no doubt the Hydra analogy helped the book. It also helps us to hypothesize a new stage at the end of the Robust Design Trend. The only problem then is does the hypothesis translate into reality?

It would have been easy to simply add the new stage onto the end of the Trend and simply wait for the world to catch up. We nearly did exactly that. If nothing else it would've sent out a message to the TRIZ/SI and broader 'research' community that the Trends aren't just about enabling different industries to catch-up with one another (i.e. a known Trend jump from one industry, stimulates a similar jump in other industries that haven't made that jump yet), but could also be used to point everyone to future jumps that none of them have yet made.

As it happens, though, we decided to wait. The wait duration was ultimately determined by the need for a number of 'real' case studies from technology, business and the natural world.

The latter of which proved the easiest to find. 'AntiFragile' solutions exist in many parts of nature. The whole field of what is now known as hormetis is all about a biological phenomenon whereby a beneficial effect (improved health, stress tolerance, growth or longevity) results from exposure to low doses of an agent that is otherwise toxic or lethal when given at higher doses. We can also see the effect in another way when we look at

(one of Taleb's main forms of exercise if the story in the book is true) weightlifting: 'over-stressing' muscles and then allowing them to recover before over-stressing them again is a very good way to build bigger, stronger muscles. Nature understands AntiFragile.

In the world of business, it's probably fairest to say that the large majority of enterprises on the planet are not AntiFragile. Most aren't even very Robust, thanks to years of 'continuous improvement'. It's difficult to find examples of human-built entities that have been designed to be AntiFragile. Finding them tends to require zooming-out and looking at bigger pictures. Like Switzerland.

Switzerland is often described as 'the most boring country on Earth'. Boring is usually a signal of unappealing, but one suspects that there are many on the planet who would very definitely prefer Switzerland's boring-ness rather than the turmoil and crisis we see everywhere else. Switzerland is a model of stability. This stability comes in no small part because, unlike most other countries, it doesn't have a big central bank or national government. What it has instead are dozens of sovereign mini-states that squabble and fight with one another constantly. The country's AntiFragility, in other words, comes because all of this micro-scale turmoil helps make the country as a whole stronger because it enables all of the small problems to be revealed and resolved before they're able to metastasize into something bigger. Like, say, the sort of kicking-the-can-down-the-road, quantitative-easing fiscal cliff that the US, EU and UK have all inadvertently climbed.

So much for the zoomed-out search for 'business' examples of AntiFragile. We can also see evidence of some of it if we look at some of the less traditional areas of business. Music or literature make for two such areas. In the world of literature, the book *Fifty Shades of Grey* has to be one of the shoddiest, badly written series of books ever written. The critics hated it, and still hate it. The problem (for the critics at least) is that the more they espouse their hatred, the more the public go out and bought the books. We see the same critic-backlash AntiFragile effect with many popular artists in the music industry. Many of the biggest bands on the planet in the 60s and 70s rose to prominence precisely because the critics told everyone they were rubbish (Bay City Rollers, Duran Duran, Osmonds, Grateful Dead, Kiss, Motley Crüe, the list goes on). *Fifty Shades Of Grey* and The Osmonds are AntiFragile, in the same way that this year's Brexit referendum is also starting to look AntiFragile – the more the 'experts' told everyone the UK was better off in the EU, the more powerful the out campaign became. The more solid the argument for remaining was, the more it has become ammunition to rubbish the 'experts'.

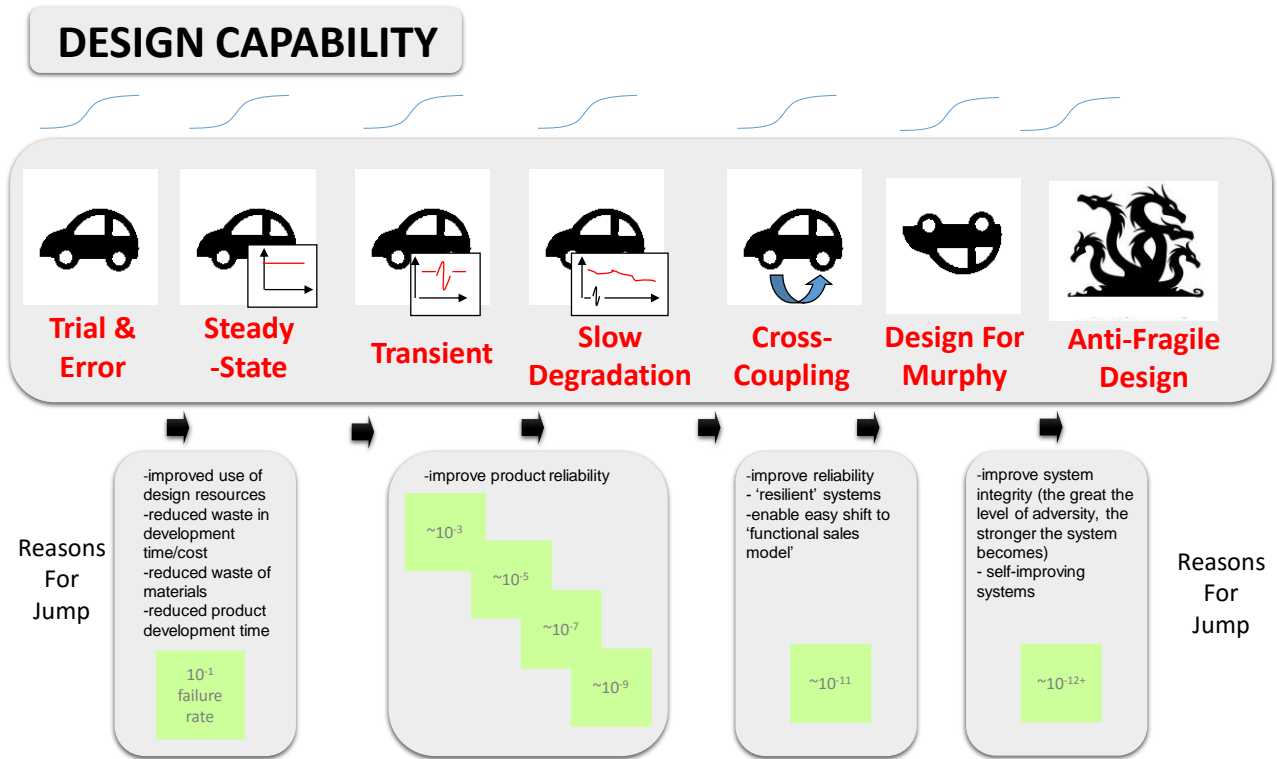
Finally, switching to the world of technology, earlier this year saw the publication of a manifesto for 'AntiFragile' software:

*The disruptive nature of the antifragile approach for open and complex systems is of greatest importance and needs to be systematized, especially for software systems. In fact, antifragile software design is becoming a research issue in the software engineering community... We propose a similar approach to Antifragility, namely we would like to define the principles ruling the building up of software systems which exploit faults and errors to become better and stronger. This Manifesto does not want to be a fixed and complete set of principles. It is an open contribution to the discussion which needs to be improved and re-elaborated. All rights related to the Manifesto are free, open and belong to the community. This work represents our suggestions urging the community to start elaborating antifragile principles to lead their implementation in real organizations.*

Some software companies, it has to be said, are already ahead of the game. They've seen the coming contradictions and have decided to do it anyway. When software writes, updates and evolves 'itself', why do we need humans to code it? The problem with

software is that it only needs to be programmed once. After that, it is able to self-replicate an unlimited number of times. Maybe to the point where the control systems used to control all the things in and around our lives, learn how to make the physical stuff AntiFragile too.

Okay, so that last part is still a way off, but that shouldn't stop us from saying that the 'AntiFragile' Trend stage well and truly exists today in many forms. Here's what we think our Robust Design Trend now looks like as a result:



And, given that 'Robust' feels like a no-longer relevant anomaly, we've decided to re-name the Trend as 'Design Capability'... now we just need to write the book... we're thinking 'AntiFragile' is the last missing piece in the jigsaw, so who knows, we'll see what 2017 brings.

# Perfect Tolerances?

*"In the landscape of extinction, precision is next to godliness."*  
Samuel Beckett

This one seems to keep coming back to haunt me. Time, I thought, to try and stem the seemingly unstoppable tide.

Manufacturing tolerances, high or low?

In Operational Excellence World, the answer is a no-brainer. Perfection is good; variation is bad. Therefore, 'continuously improve' by progressively tightening the tolerances, and, better yet, make everyone aim for the middle of the target. In theory, too, if we do the job right, there should be no impact on cost. 'Quality is free.'

Well, it is, if organizations understood the concept of solving contradictions. But that's something that tends not to be a part of the Operational Excellence world, so it tends not to happen. That was certainly the case with a recent experience working on a problem with a client.

Without getting in to too many details, the problem we were tasked with solving involved an electric motor with an output shaft which, for a variety of reasons, had to have its axial position controlled very accurately. That's 'accuracy' as in plus or minus less than a micron. The original manufacturers of the electric motor had done a very competent job of controlling their manufacture processes in order to maintain the required positional tolerance during operation. Unfortunately, the cost of the motor was very high. Because the company decided they couldn't bear this cost any more, they decided to out-source manufacture to a part of the planet where the manufacture costs were known to be lower. Several companies in the country concerned put in bids to take over the manufacture. The cheapest credible bid was a factor of five cheaper than the original cost of the motor. They got the contract. They started making motors. Very quickly it became apparent that, contrary to their promise, they were not able to manufacture to the required tolerances, and hence the axial position of the shaft was not able to be controlled to anything like the right levels.

The out-source company was told they had better fix the problem. Still in Operational Excellence mode, they decided the only way to get everything within tolerances was to buy some new manufacture equipment. A bit like the factor-five cost problem with the motor, the new equipment, purportedly able to achieve the required tolerances, was almost five times the cost of the equipment the company had paid for their existing equipment. They couldn't afford the price. They also couldn't afford to lose the contract. Operational Excellence Stalemate was reached. Everyone was stuck.

Whenever I look at any technical problem like this, my instincts tend to take me straight to the Trends Of Evolution. And when it's a manufacture tolerance problem, my mind goes direct to two Trends in particular. The 'Macro To Nano' Trend (Figure 1) is a trend that, in theory at least, tells me that things get smaller. More specifically, 'the smallest engineering dimensions get smaller to in order to deliver a functional benefit'. This is the trend that's supposed to tell me that smaller tolerances is the 'right direction'.



Figure 1: Macro To Nano Trend

On the other hand we have the Dynamization Trend. It would also seem to have something to say about the tolerance question. Especially, in this specific case, in terms of whether the right thing to do is to stop the motor shaft from moving axially – Figure 2.

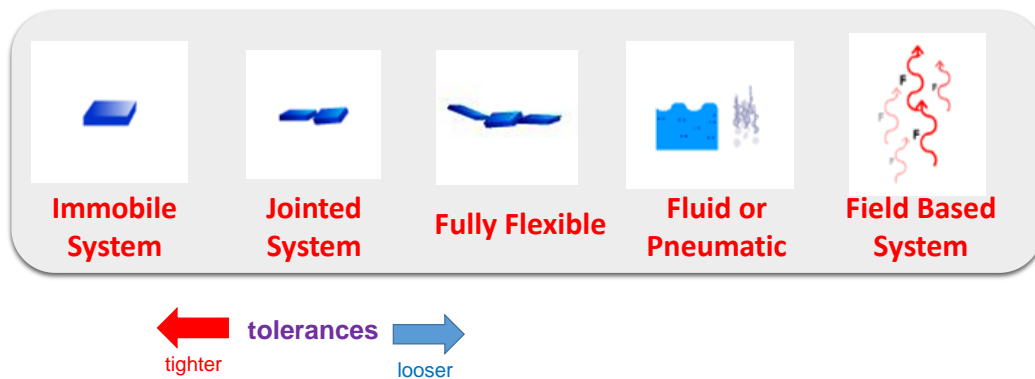


Figure 2: Dynamization Trend & 'Tolerances'

Now, admittedly, this connection between Dynamization and 'tolerances' is not so obvious, but once we make it, the Trend is very definitely trying to tell us that the tighter we make our tolerances (the more we 'immobilise' the system), the further from IFR we are moving. The Dynamization Trend tells us that physical things become more ideal as they become more flexible. Tolerances 'want to become flexible' in the same way that structures and other things that engineers and architects tend to want to 'stiffen' want to become movable and adaptable.

It would appear that, when it comes to tolerances, the Macro-To-Nano Trend and the Dynamization Trend are in conflict. Which might seem a little odd. If both Trends represent signposts towards the Ideal system, why are the signposts apparently saying different things?

Sounds like a contradiction. We want tolerances to be 'tight *and* loose'.

Sounds like something that requires a separation on condition strategy to solve: we want the tolerances to be tight *if* the component (per the Macro-To-Nano Trend) is becoming smaller; we want the tolerances to be loose (per the Dynamization Trend) *if* we wish to reduce manufacture cost, increase the adaptability of the system and increase the resilience of the system.

Plus, of course, we know that the Dynamization Trend sits at the top of a hierarchy of Trends. If we couldn't solve the contradiction, the looser tolerance direction should win because that's the direction the Dynamization Trend tells us to travel.

Now, I should say, when I tried to have this discussion with my client, all I seemed to get back were furrowed brows and looks of confusion. 'What has this got to do with my motor

problem?' I could see them thinking, 'Do we have to buy some expensive new machines or not?'

Answer: Not.

What does the 'tight *and* loose' problem statement mean in terms of the motor shaft?

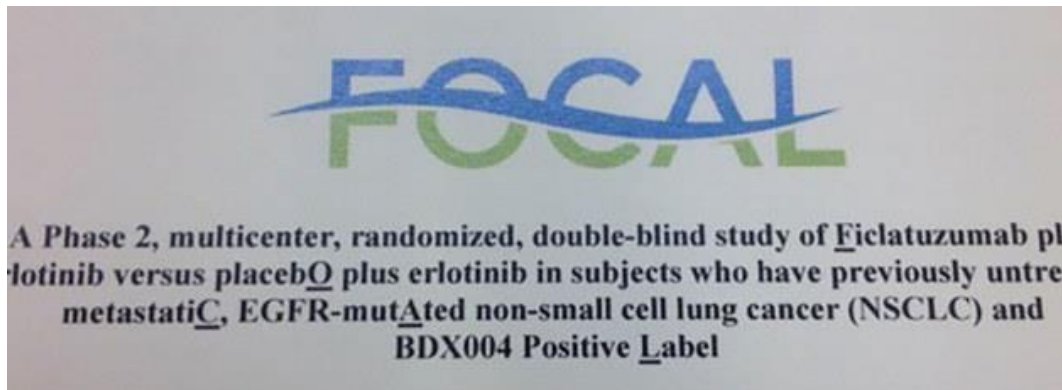
It means – in an ideal world – a) we are able to manufacture the motor with the existing machinery and with the current 'too loose' tolerances, *and*, despite the shaft potentially being able to drift axially, it somehow maintains the required constant axial position. "The loose-tolerance shaft aligns itself."

Needless to say, when we re-framed the problem in this way, the whole story became a whole lot easier to not only imagine, but also, solve. A simple look at some of the other Trends and some of the features of the motor and what the motor shaft had to align with highlighted several geometric features and untapped resources already present in the system (e.g. the shaft was running open to the atmosphere and so was fundamentally surrounded by air) that could very easily be configured to make sure the shaft remained exactly where the application needed it to be.

The moral of the story, as I've been trying to impress upon every engineer and designer I see that I realize have been taught the opposite, is that tight tolerances are a last resort and should only ever be allowed as a solution if the overall system is making a jump towards a smaller size-scale... and, even then, will only be a temporary fix. The ideal system is made terribly and performs perfectly. The ideal system aligns 'itself', balances itself, compensates itself. All 'tolerance' questions are ultimately red herring questions. Despite what the Operational Excellence World and, in particular, the Six Sigma community might have to say on the matter.... Now there's a tide worth fighting.

## Not So Funny – Acronautics

Acronyms are good. Acronyms solve contradictions: we want to communicate a big message in a small number of letters. Inventive Principle 2. Simple. Or is it?

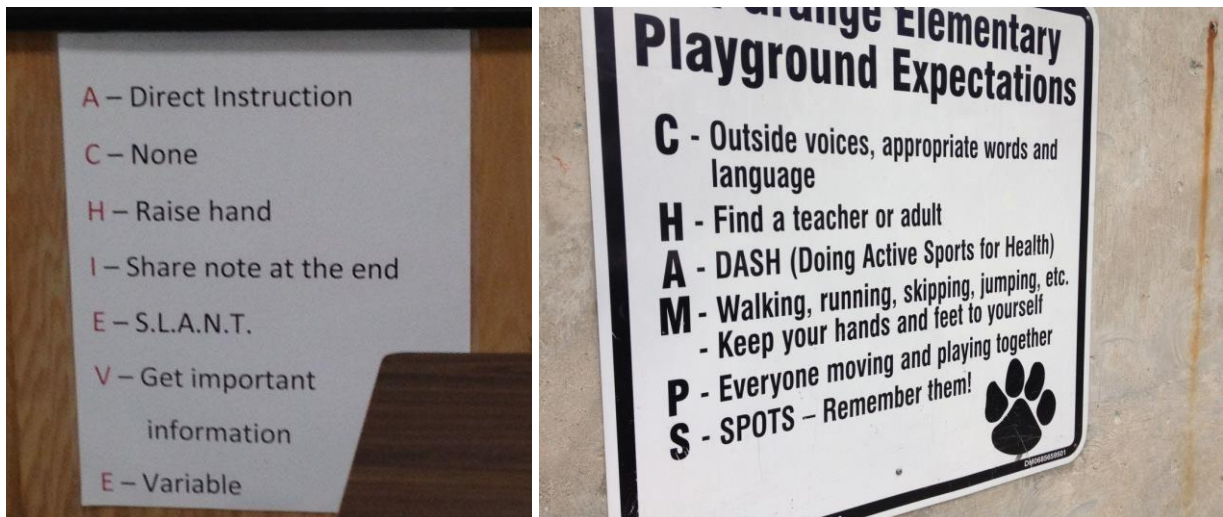


I can't quite work out how 'Focal' started. Does the message dictate the acronym or does the acronym dictate the message? Here's a cunning example of the latter...



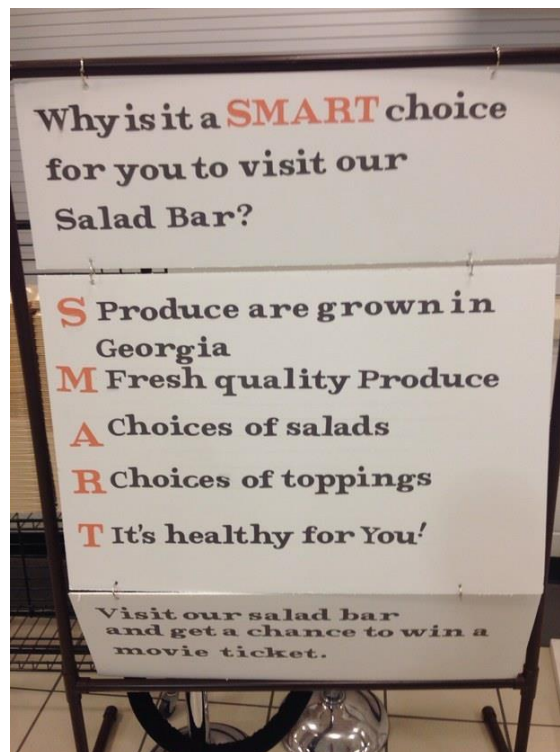
Finding words beginning with 'T' is difficult, right? Solution: remember a picture speaks a thousand words, so insert an appropriate graphic. Or, if that doesn't work, insert an inappropriate one.

Sometimes, though, it's difficult to find any words that seem to fit. No need to worry though...



Teachers. You have to admire them. Champs one and all. And managing to get an acronym within another acronym (Inventive Principle 7 already), that's what I call Meta. Or S.L.A.N.T.

This one has the same overall idea, but manages to go just that little – smart – step further:



Dial M for 'fresh quality produce'. Obviously.

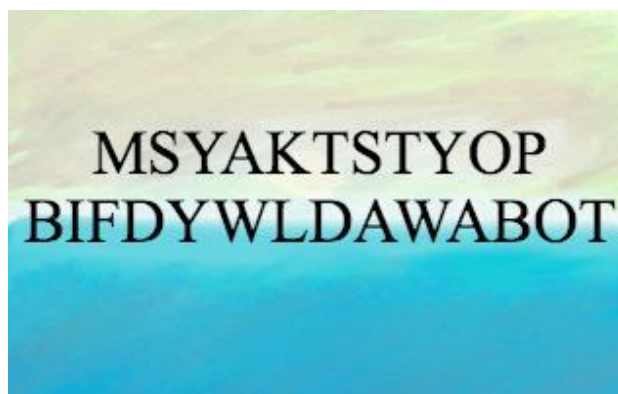
Okay, this one manages to find words that begin with the right letters, kind of, and the acronym ticks the memorable box. Probably the wrong kind of word to get people to keep at the front of their minds, though. See what you think...



C for create. I get it. Not Calm. That should really help. Something like this...



FAFFC. Yep, I'm with you. Don't forget the Fries!  
No chance of forgetting this one...



'make sure you always know the solutions to your own puzzles because if you don't you will look dumb and waste a bunch of time'. I'm surprised you didn't get that one sooner.

At least you knew what an acronym was though. Unlike some people I could mention.



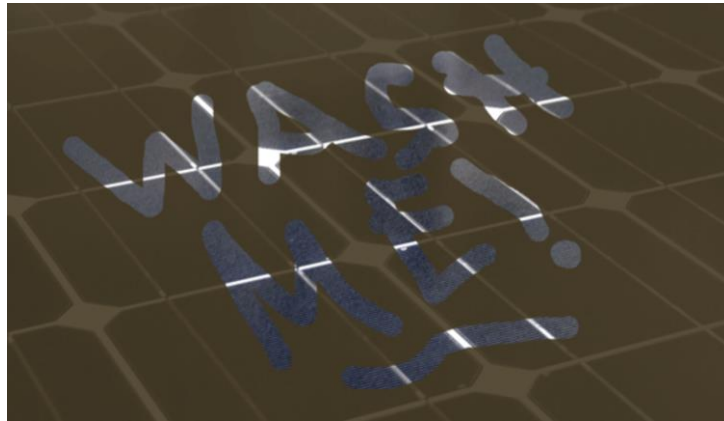
If in doubt, throw in a bit of Principle 17. And forget about the whole acronym shenanigans thing. Way too complex. Just keep the 'I.T.' bit, people will get that. People that work in our Ndepartment will, anyway.

Finally, some people seem determined to go the whole (Principle 13, double-bluff) hog...



Tcch.

## Patent of the Month – Self-Cleaning Solar Panels



Patent of the month this month comes from an inventor at Boston University. The solution was first revealed to the world back in 2014, but it took until 6 September for US9,433,336 to finally be granted. The patent title pretty much gives the game away as far as the purpose of the invention is concerned. The background section of the document offers up a clear (no pun intended) description of the problem to be solved:

*Solar photovoltaic (PV) and solar photothermal (PT) systems can meet global electrical energy needs. However, due to solar energy's low power density, megawatt to gigawatt scale PV/PT plants require a large area for installations and are best suited for semi-arid and desert regions. These areas are the sunniest but also the dustiest locations in the world. Deposited dust strongly adheres to solar panels and solar concentrators and obscures the solar radiation reaching the PV cells and mirrors, reducing energy conversion significantly. Deposition of only four grams of dust (with particle size in the range from 0.5 to 10  $\mu\text{m}$  in diameter) per square meter on a panel may reduce power output by 40%.*

*U.S. Pat. No. 6,911,593 of Mazumder et al. (by the way, an earlier invention by the current inventor) describes an electrodynamic shield embedded within a thin transparent dielectric film or a sheet used to remove dust deposited on solar panels.*

*Some of the major difficulties in applying EDS on solar panels include (1) avoiding interactions between the electric field of the EDS electrodes and current collecting grids used in solar panels for providing electrical power, (2) scaling of the method of EDS construction for manufacturing and installing transparent electrodes on solar panels and solar concentrators, (3) obscuration of solar radiation caused by the placement of the EDS on the surface of solar panels and concentrators, (4) retrofitting existing solar photovoltaic and photothermal devices with self-cleaning EDS systems, (5) environmental degradation of polymer films under outdoors condition, (6) maintaining the efficiency of heat dissipation of solar panels integrated with EDS, and (7) cost-effective manufacturing of new solar panels and solar concentrators integrated with electrodynamic screens for large-scale installations.*

*Efforts to maintain solar panels and solar concentrators clean have been investigated by a number of researchers. However, the current methods are limited to manual cleaning of solar collectors with water and detergents. A soft brush with a long handle is generally used. Some reported technologies on self-cleaning glass involve passive surface treatment methods to modify the front surface to be either highly hydrophilic or highly hydrophobic.*

*One commercial product available for building applications is the hydrophilic self-cleaning glass coated with a thin layer of photoactive crystalline titanium dioxide ( $\text{TiO}_2$ ) particles. When UV radiation is incident on the  $\text{TiO}_2$  coated glass, the surface becomes highly hydrophilic and its moisture absorbing capacity increases substantially. When the surface is cleaned with water or is exposed to rainfall, the wetting characteristics of the glass plate help the surface to be easily*

cleaned. Deposited dust can be washed away due to the super hydrophilic property of the glass. However, the process has major limitations: (1) there is high reflection loss of sunlight since the refractive index of  $TiO_2$  is higher than that of the glass, (2) water (or rain) is needed to remove the dust, and (3) presence of UV radiation (wavelength shorter than 380 nm) is needed to activate the surface. In semi-arid and desert areas water is scarce and rainfall is infrequent.

Application of highly hydrophobic surface has also been reported for minimizing adhesion of dust on glass plates. Super hydrophobic transparent films or plates based on nanostructured properties have very low surface energy, which minimizes van der Waal and capillary adhesion forces between the dust particles and the glass surface. The electrostatic forces of adhesion are not decreased. When exposed to outdoor conditions the hydrophobic properties of the surface are adversely affected by UV radiation and dust deposition, limiting the durability of super hydrophobic surface less than a few months.

Methods involving mechanical cleaning of panel surfaces by applying vibration, using wipers, moving transparent films over the panel surface, and using water have also been reported. Applications of electrostatic and electromagnetic fields for controlling particle motion have also been published. However, these reports have tended not to address the development of manufacturing processes involved in the fabrication and installations of electrodynamic screens (EDS) on solar panels and solar concentrators (mirrors and lenses) for removing dust and providing self-cleaning properties of solar photovoltaic (PV) and solar photothermal (PT) systems.

So, the basic problem is how to get dust off the surface of the panel without the time, cost, and especially energy of current systems. Here's how we might best map that onto the Contradiction Matrix:

IMPROVING PARAMETERS YOU HAVE SELECTED:

Loss of Substance (25)

WORSENING PARAMETERS YOU HAVE SELECTED:

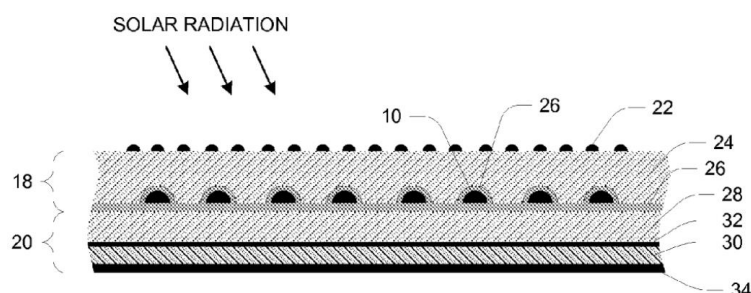
Energy used by Stationary Object (17)

SUGGESTED INVENTIVE PRINCIPLES:

12, 18, 28, 35, 30, 24, 31, 19

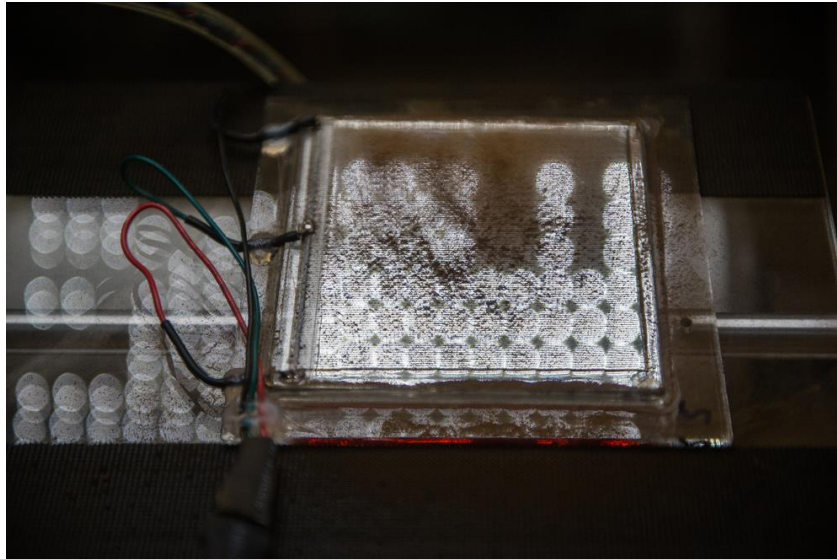
And here's how the inventor has solved the problem:

...a film assembly is disclosed that is usable to self-remove particles of material such as dust deposited thereon. The film assembly includes a transparent fluoropolymer film and a set of elongated conductive electrodes carried by the film. The electrodes are configured to be connected to a source of pulsed electrical power and to generate an electric field across a surface of the film in response to the pulsed electrical power. The electric field is of sufficient strength to remove the particles from the surface. The electrodes are separated from adjacent portions of the film by a coating of a dielectric material having substantially higher dielectric strength than a dielectric strength of the film to protect the film from dielectric breakdown during operation.



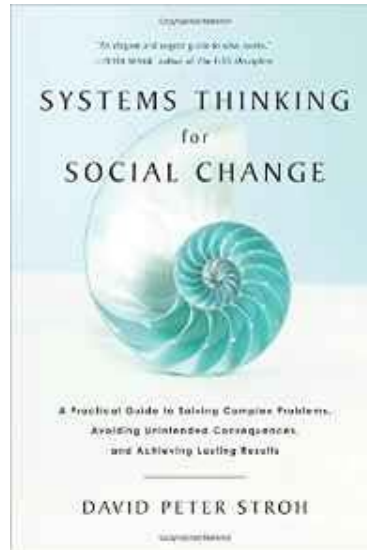
Clear illustrations of Principles 28 (Mechanics Substitution – the electrodynamic field), 30, (Flexible Shells & Thin Films – the film layers), 19 (Periodic Action – the pulsed field) and 24 (Intermediary – the dielectric layer).

So, hopefully, the invention makes for a very nice illustration of contradiction solving. Somewhat more importantly, the invention solves a real problem, and does it in a very simple way. Better yet, the university has done a pretty good job of showing the world what they've done and demonstrated the solution working very impressively. Including a couple of short videos. Check out <https://www.bu.edu/otd/company-profile/self-cleaning-solar-panels-2/>



The field always wins, right?

## Best of the Month – Systems Thinking For Social Change



If you're familiar with TRIZ/SI, reading management text-books usually makes for a lot of frustration. 'If only the author knew about solving contradictions', is a typical thought. 'If only they knew about Perception Mapping', is another. This month's book choice suffers from both of those problems. The whole thing could have been a lot more powerful than it has turned out to be.

As it is, things don't get off to a good start, either, when the author decides it is necessary to devote the first three chapters to listing out reason why systems thinking is good. Methinks he doth protest too much. I know the book is targeted at newcomers to Systems Thinking, but when someone tries to push something down your throat, it tends to create an unfortunate reflux reaction, so probably ends up doing the opposite of what it should. If you already know about 'systems', you may wish to skip straight to chapter 3; if you're thinking about passing the book to someone you wish to introduce into the world of systems, you may wish to tell them to do the same thing.

So far so bad. I nearly gave up, but fortunately, Chapter 4 turns out to be pretty good. That's a 'pretty good' as in, 'contains some useful insight. What Stroh does in this chapter is collate a comprehensive suite of system problem archetypes. A lifetime's experience working on public sector system problems – like homelessness, crime reduction, education – has allowed Stroh to realize that the same problems keep recurring again and again. In all, Chapter 4 identifies thirteen of these archetypes. Taken together as a collection, my instincts tell me that they probably describe 95% of all complex system problems, not just in the public sector, but across all walks of human life. Here's the list:

Archetype	Characteristics
Virtuous/Vicious Cycles	Amplification and reinforcement: a reinforcing process producing success or disaster
Balancing Process	Correction: we try to reduce the gap
Fixes That Backfire	Unintended Consequences: the long term negative consequences of a quick fix
Shifting The Burden	Unintended Dependency: the quick fix we become addicted to
Limits To Growth	Unanticipated Constraints: the limiting mechanism

	on spiraling growth ('top of the s-curve')
Success To The Successful	Winner Takes All: your success produces my failure
Accidental Adversaries	Partners Who Become Enemies: two parties want to cooperate, but each sees the other undermining its success
Drifting Goals	Inadvertent Poor Performance: actual and desired performance levels gradually fall
Competing Goals	Conflicting Or Multiple Commitments: trying to satisfy conflicting goals or achieve too many can lead to accomplishing none
Escalation	Unintended Proliferation: the harder you push, the harder the competitor pushes back
Tragedy Of The Commons	Optimizing Each Part Destroys The Whole: everyone takes advantage of a resource that doesn't belong to anybody
Growth/Underinvestment	Self-Created Limits: we push on the growth side and underinvest in the capacity to grow
Bathtub	Flow Is As Important As Stock: level of water in a bathtub is governed by the relative flow of water in and out

Admittedly, the models Stroh uses as the templates for each of the thirteen archetypes is a little awkward ('if only he knew about Perception Mapping...'), but nevertheless serve as, a good start point. A reminder, if you like, that when dealing with complexity, there isn't always the need to start from a blank sheet of paper.

Chapter 4 is what makes the book worth picking up. After this chapter, things head downhill again. I agree with Stroh's point that the main benefit of constructing system models involving all of the relevant stakeholders is the structured discussion it helps provoke. I also agree with his comment that the systems models, once drawn, are not so obvious that they make sense to someone looking in at a situation from outside (as a reader of the book, I found myself spending more time trying to make sense of the pictures as I did reading the words around them). Stroh doesn't manage to get too further than motherhood statements when attempting to suggest solutions ('involve people early', right, thanks for that), but at least he doesn't try and push the problem under the carpet.

A good system model takes you half way to the solution. Sometimes, in the case Stroh describes, when stakeholders step back and look at the maps they've drawn, the solutions become obvious. When the solution doesn't appear obvious ('if only he knew about solving Contradictions'), Stroh does at least make an attempt to do a mini version of TRIZ and, for the main archetypes at least, catalogues a few sensible solution directions that teams working on such problems might like to explore. It's not great, but it is better than most management books. And most 'systems' books for that matter. It's rare that an author is able to bring to bear a knowledge that covers several decades. And its rarest of all that the author is able to step back far enough from that experience and see a bigger picture.

Systems Thinking for Social Change isn't the best book in the world, but it's the best we could find this month. Which is something.

## Wow In Music - Tragedy



Yes, that 'Tragedy'. A guilty-pleasure of a song if ever there was one. It was a number one hit single for the Bee Gees, however, in over a dozen countries around the world, so they must have been doing something right.

Several things, I suspect, but the one I'm interested in this month is a semi-hidden wow that Tragedy shares with lots of other hit singles. Del Shannon's biggest hit, 'Runaway' has it, Sly and the Family Stone's blockbuster 'Thank You Falettinme Be Mice Elf Again' has it, Chic's biggest hit, 'Good Times' has it, Tears For Fears, 'Everybody Wants To Rule The World' has it. Something like 20% of all hit singles of the last 30 years have it. It's a trick that seems to work nearly every time.

'It' being a 'pre-chorus'. Unlike many of the musical 'wow's we feature in this section of the ezine, pre-choruses aren't so much about a moment or short phrase within a piece of music, but rather something that alters the overall structure of the music.

Most popular songs prior to Runaway (1961) featured verses and choruses. The two basically alternated with each other. Maybe, there were two verses before the chorus, to add a little pre-chorus tension. And maybe there was a bridge somewhere along the line too to add variety. The chorus was the bit we were all supposed to sing along to. But the transition didn't always sound right. There were limits on how far away the melody of the chorus could deviate from the melody of the verses.

The pre-chorus became the answer. An Inventive Principle 24, Intermediary, device that allowed a bigger, more dynamic transition to take place. The chorus could become bigger and more memorable.

Here's what it looks like on Runaway, where 's' and 'r' represent the verse ending, 'd' represents the pre-chorus, and 'c' denotes the chorus. If you were born a Baby Boomer, in the West, whether you like it or not, you can sing along to the words and experience what an early pre-chorus sounds and feels like.

|i |./ |VII |./ |VI |./ |V |./  
 As I walk along, I wonder what went wrong with our love, a love that was so strong. **s** (8m)  
 |i |./ |VII |./ |VI  
 And as I still walk on, I think of the things we've done together, **r** (8m)  
 |./ |V |./  
 a-while our hearts were young.

|I |./ |vi |./  
 [I'm walkin' in the rain] [tears are fallin' and I feel the pain] **d** (8m)  
 |I |./ |vi |./  
 [Wishin' you were here by me] [to end this misery]

|I |./ |vi |./  
 And I wonder, I wa-wa-wa-wonder **c** (16m)  
 |I |./ |vi |./  
 Why, ah-why-why-why-why-why she ran away  
 |IV |./ |V |./  
 And I wonder where she will stay:  
 |I |IV |I |V  
 My little runaway, run-run-run-run-runaway.

Here's the Bee Gees version of the same 'srcd' pre-chorus structure as used in Tragedy. You might have to be a slightly younger Boomer or, more likely, a Nomad to sing along to this one (if you're the latter, you might like to look around you and make sure no-one is listening, your musical credibility could be in jeopardy):

**V<sub>1</sub>** (8m)  
 |I |./ |./ |./  
 Here I lie in a lost and lonely part of town. **s**  
 |I |./ |./ |./  
 Held in time, in a world of tears I slowly drown. **r**

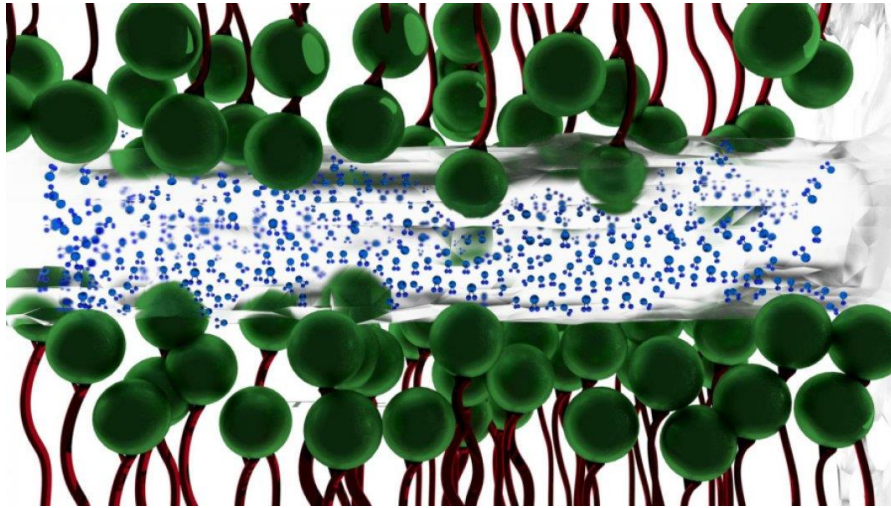
**P** (9m)  
 |II |./ |III |./  
 [Going home, I just can't make it] [all alone, I really should be] **d**  
 |II |./ |IV |./ |./ (6 beats)  
 [Holding you] [holding you] [Loving you] [loving you]

**C** (16m)  
 |i (key of vi:) |v  
 Tragedy! When the feeling's gone and you can't go on, it's **c**  
 |i |v  
 Tragedy! When the morning cries and you don't know why  
 |VI<sup>7</sup> |./  
 It's hard to bear with no one to love you;  
 |i |iv/<sup>6</sup> V  
 You're going nowhere.  
 Tragedy! When you lose control and you got no soul it's  
 Tragedy! When the morning cries and you don't know why  
 It's hard to bear with no one beside you;  
 You're going nowhere.

A battery of momentum- and expectation-building devices is unleashed in the 'holding you, loving you' pre-chorus: tonic stasis is broken by a new harmonic progression; the melody surges higher; support vocals are added; the lyric is fragmented into 2-bar and then 1-bar units; and all of this culminates in a dramatic, extended pregnant pause. The chorus is built up and anticipated, its status as primary material and fulfillment of the expanded srcd pattern asserted, long before it is heard. Clever stuff, right? You're allowed to say yes. Principle 24 rules!

Read more here: <http://www.mtosmt.org/issues/mto.11.17.3/mto.11.17.3.summach.html>

## Investments – Anti-Friction Fluidics



New research by scientists at The University of Akron (UA) shows that a nanometer-thin layer of water between two charged surfaces exhibits ice-like tendencies that allow it to withstand pressures of hundreds of atmospheres that in turn could lead to better ways to minimize friction in a variety of settings.

Why water between two surfaces does not always simply squeeze out when placed under severe pressure had never been fully understood. The UA researchers discovered that naturally-occurring charges between two surfaces under intense pressure traps the water, and gives it ice-like qualities. It is this ice-like layer of water -- occurring at room temperature -- that then lessens the friction between the two surfaces.

"For the first time we have a basic understanding of what happens to water under these conditions and why it keeps two surfaces apart," says Professor Ali Dhinojwala. "We had suspected something was happening at the molecular level, and now we have proof."

The discovery could lead to improved designs where low friction surfaces are critically important, such as in biomedical knee implants, and in a variety of high duty motor applications.

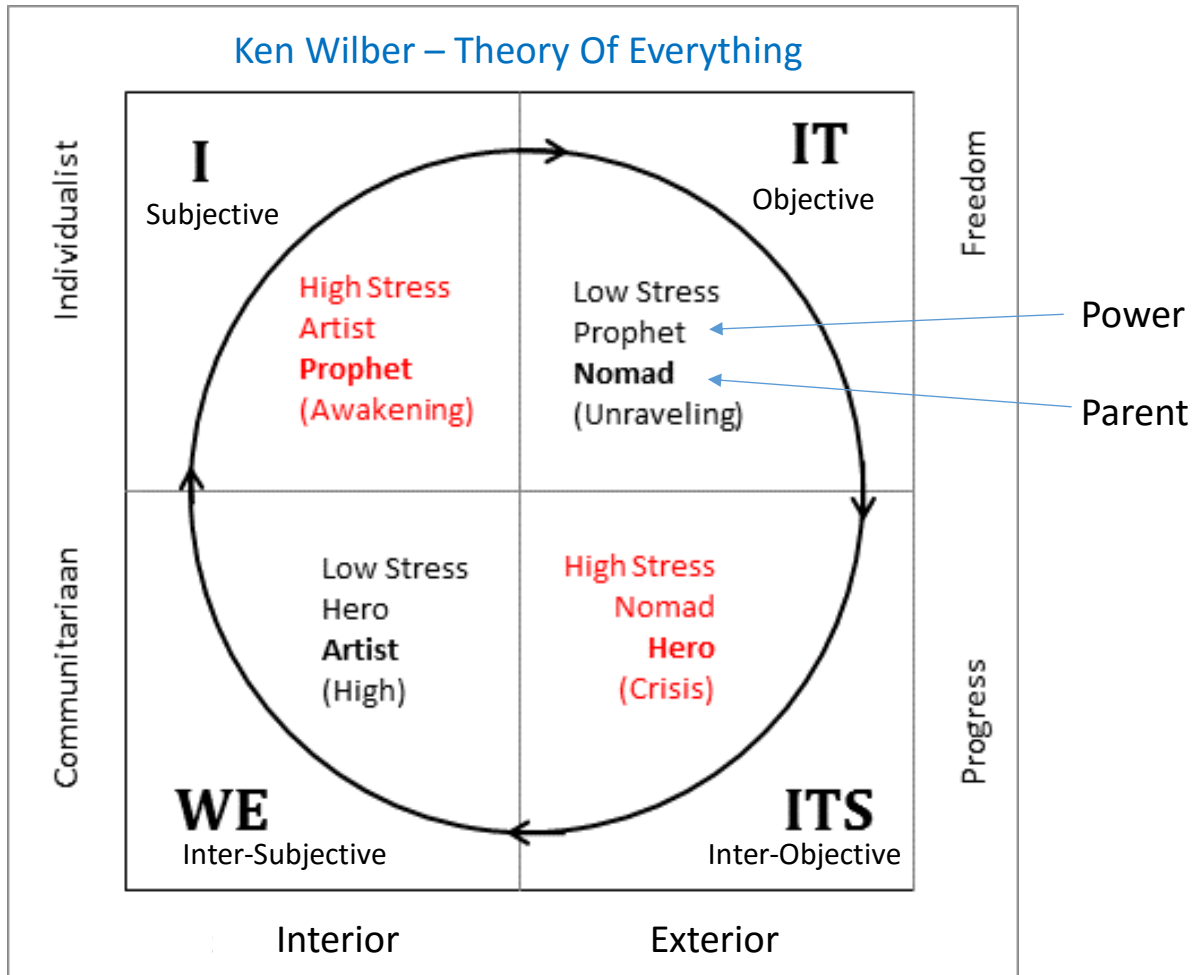
Graduate student Adrian Defante, who was also part of the research team, says "the newfound properties of water might also contribute to the development of more effective antimicrobial coatings."

Thinking more laterally, Dhinojwala adds that the research conversely offers insight into how water might be kept away from two surfaces, which could lead to better adhesives in watery environments. Which might just eventually turn out to be the biggest commercial opportunity. And, would make for a lovely new illustration of the rarely observed Inventive Principle 33, Homogeneity, in action – solve a water problem using water. Does that also count as an 'existing resource'?

The study by Dhinojwala and his team can be found in the current issue of *Science Advances*: N. Dhopatkar, A. P. Defante, A. Dhinojwala. **Ice-like water supports hydration forces and eases sliding friction.** *Science Advances*, 2016; 2 (8): e1600763 DOI: [10.1126/sciadv.1600763](https://doi.org/10.1126/sciadv.1600763)

## Generational Cycles – Theory Of (Generational) Everything

When Ken Wilber drew together his 'integral vision' Theory Of Everything thoughts and assembled the over-arching I-IT-ITS-WE framework, I don't think he had in mind any connection to Strauss & Howe's work on generational cycles. I'm not sure either that he made a connection to the manner in which society might be dominated by one or other sector of the model according to different times in generational history. When we try and connect the two, I think it looks something like this:



The picture contains a lot of detail. Perhaps a good place to start is to explore the connection between Wilber's four quadrants and the four turnings of the Strauss Howe model:

Post-crisis, society's new s-curve is known as a 'High' Period. This is the bottom-left quadrant of Wilber's model. It's a 'WE' dominated period, with the Hero generation in their period of power ('everyone needs to pull together'), and the Sensitive, young-adult Artists sacrificing their personal desires to do what needs to be done.

Then comes the Awakening period, a period of high stress as the idealism of the High period receives its first shocks (e.g. the Kennedy assassination). It is a period of high uncertainty and stress. The Artists are now in charge, and are out of their depth. The Prophet generation (Baby Boomers) have now grown up and are realizing that those in

power aren't up to the job, and so the very I-like 'consciousness revolution' turns into disillusionment and the start of 'every man for themselves'. The idealism of their childhood turns into a Narcissistic focus on themselves – it's all about the 'I'.

Focus on the Individual continues into the third turning, the Unraveling. The focus on the individual continues, but now shifts away from the 'internal' to the external, 'IT'. It is a period of materialism and grasping to see who can collect the biggest pile of toys.... the Prophet Boomers were in power, and it's what they decided was the right way to do things...

...this then turns into the fourth turning, Crisis. The newly in-power Nomads realize that the Pragmatic thing to do is to work together to sort things out. The younger Heroes, have been brought up to work together, and when they realize this is the only way they will get to be the heroes they so keenly want to be, they begin to sacrifice their personal heroics and focus on fixing the ('ITS') crisis.

As with all things complex and all things 'societal', there is no such thing as black-and-white. It's all about ebbs and flows, pulses and oscillations. Looked at through this kind of lens, it seems to me that Wilber's model and the four turnings of the Strauss & Howe generational model have a lot of new insight to offer. I think we might be hearing more about this model in the coming months.

## Biology – Luna Moth



The long hindwing tails sported by many moths have long been suspected as a strategy to confound predators. The moths are active mainly at night, so they don't need a visual disguise, rather they need to avoid nocturnal hunters that navigate by sound.

Researchers at the University of Washington and Johns Hopkins University took a detailed look at the acoustics of the common luna moth (pictured above), to see how long tails could throw off predators that use echolocation to pursue prey. Results published in the *Journal of the Acoustical Society of America* suggest a strategy for how even a fairly small tail could confuse bats on the hunt.

"The interesting thing about these tails is they are not just extensions, there is a twist toward the end," said first author Wu-Jung Lee, "we think that twist could be a key for how the tails function acoustically."

The study shows that without any tail, the echo center is a bullseye right on the moth. But the twisted tail creates an echo from all directions that tends to shift the echo cloud past the tip of the moth's body. With the tail's reflection, about 53 percent of the time the echo center from experimental chirps fell past the tip of the moth's abdomen. "If the bat always aims for the highest-amplitude echoes, there's a very small percentage of the time that the tail echoes would be dominant," Lee said. "But maybe by displacing the echo center, that can do the trick."

A difference study, led by Boise State University, found that the big brown bats are about 47 percent more successful at hunting Luna moths that have lost their tail, showing that the moth's extended tail somehow helps it survive. Those authors believe that the tails serve a role in acoustic deflection, and show that moths have evolved extended tails independently on different continents, suggesting it offers a key advantage.

The new research, carried out in parallel with the Boise study, explores the acoustics in more detail. To analyze how sound waves bounce off the moth, the researchers aimed short chirps similar to the ultrasonic pulses that bats use to navigate and capture insects. The pulses had frequencies that cover the hearing range of bats and are beyond the

range of human hearing. While the 3-millisecond experimental chirps provided only fuzzy echoes from the tethered flying moths, Lee applied common signal processing techniques to sharpen the resolution to 1 centimeter, about a third of an inch, which gives a clear image of a 10-centimeter luna moth. The goal was to create a bat-centered view of the moth, although, "we don't know what type of signal processing the bats are using," the researchers say. By analyzing the returned echoes and comparing the signal strength with video footage of the flying moth, they found the tail doesn't provide a strong false target to replace the moth's body. This is not surprising, since the tail is much smaller than the abdomen or wings. But the echo off the wings varies a lot depending on where in the moth's wingbeat the chirp strikes. If the wings are perpendicular to the incoming chirp sound waves, it creates a big echo, but if they are parallel the wings offer a very small target. The moth's twisted tail, on the other hand, provides a consistent acoustic response regardless of the angle, which could create confusion around the varying main echo. "No matter which angle you hit the tail, you usually have some area," Lee said. And if a bat was confused about the exact position of its prey, it might go for the center of several echoes. The twisted tail significantly throws off such an estimate, meaning the bat is more likely to miss.

"A moth is a very complicated object in space," Lee said. "It could be difficult for a bat to track each individual point of the echo cloud. It would be much easier for it to say, 'There's a ball of echoes coming back, I'm going to hit the center of it, and maybe I'll catch something.'"

Here's what the luna moth's cunning twisted-tail conflict resolution strategy looks like when mapped on to the Contradiction Matrix:

IMPROVING PARAMETERS YOU HAVE  
SELECTED:  
**Ability to Detect/Measure (49)**  
WORSENING PARAMETERS YOU HAVE  
SELECTED:  
**Area of Moving Object (5)**  
SUGGESTED INVENTIVE PRINCIPLES:  
**26, 28, 13, 2, 17, 32, 24, 18**

In simple terms, the moth is trying to reduce its likelihood of being detected, and the thing that prevents that from happening is its bat radar cross-sectional area. Good to see that Principle 17, Another Dimension is high up the list of useful strategies for solving the problem. In fact, the luna moth has made two uses of the Principle – one to elongate the tail, and the other to twist it. Lovely stuff.

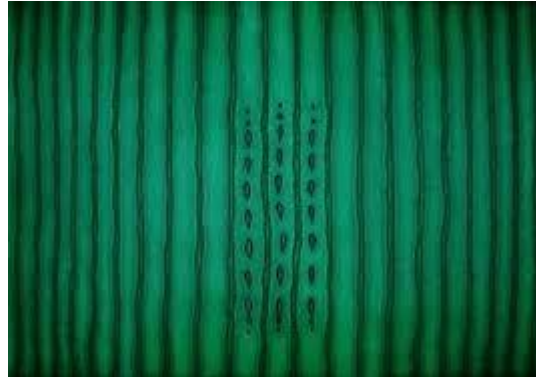
#### Read more:

Wu-Jung Lee, Cynthia F. Moss. **Can the elongated hindwing tails of fluttering moths serve as false sonar targets to divert bat attacks?** *The Journal of the Acoustical Society of America*, 2016; 139 (5): 2579 DOI: [10.1121/1.4947423](https://doi.org/10.1121/1.4947423)

## Short Thort

*“The saddest aspect of life right now  
is that science gathers knowledge faster  
than society gathers wisdom.”*

Isaac Asimov



*“We are homesick most for the places we have never known.”*

Carson McCullers

## News

### IRDG, Dublin

The Industry Research & Development Group in Ireland are holding their annual conference in Dublin on 27 October. Darrell will be presenting a keynote (‘Surfing The Edge Of Chaos: Innovation In An Operational Excellence World’) and a couple of mini-workshops (‘The Seven Habits Of Highly Effective Innovation Projects’). Check out the full agenda and sign up here: <http://www.irdg.ie/irdg-annual-conference-2016/>

### University Of Buckingham MSc

The start of the brand new ‘Lean Design & Systems Innovation’ degree programme looks like it has been delayed until March 2017. The website looks like it will go live at the end of this month, but anyone wanting more ‘unofficial’ details in the meantime might like to contact Darrell.

### New Projects

This month’s new projects from around the Network:

- FMCG – PanSensic Market Launch Evaluation Study
- FMCG – Technology Road-mapping Project
- Industrial – Problem-Solving Project
- Education – PanSensic Dashboards
- Automotive – Innovation Project
- Government – High-Potential Start-Up Technology-Matching Project
- Publishing – TrenDNA workshops
- Medical Devices – Patent Bulletproofing Project
- Financial Services – PanSensic Study