

IDEALITY AND 'SELF-X'

Part 2: Meals, Wheels, and Carpet Slippers

Technical Case Studies

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Introduction

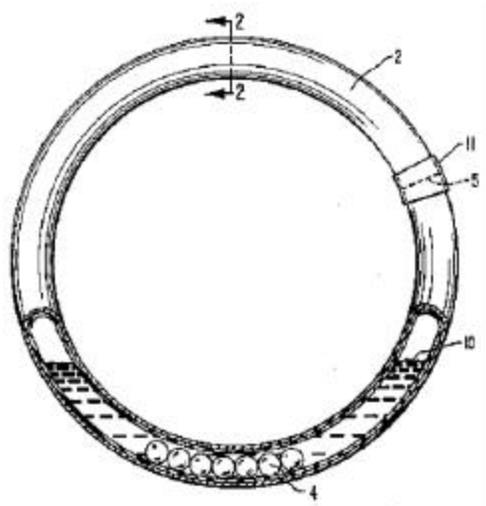
This article forms the second in a series of three discussing the importance of systems that incorporate solutions incorporating the word 'self' – self-cleaning, self-balancing, self-aligning, etc – in the context of their relationship – in the true TRIZ sense – to the concept of ideality. This second article illustrates a number of technical examples of inventions and solutions built on the self-x concept discussed in the first article. Each of the case studies is intended to both show the importance of 'self' as a solution direction, and also some of the important additional implications of thinking about this word in an innovation context.

Case Study 1 – Self Balancing

The first case study to be considered involves a subject that has been discussed on several occasions in TRIZ texts (Reference 1, 2). The focus of the situation is the balancing of systems designed to rotate. These systems can span a range from jet-engines to electric toothbrushes from washing machines to car wheels. In each case, designers have to make considerable compromises in order to achieve 'acceptable' performance of these systems. This is particularly evident when attempting to design for reliability over long periods of time when things within the system may change and thus create out-of-balance loads and forces. In the case of the jet engine it means customers face expensive maintenance and overhaul bills (for the engine manufacturer, the cost of producing and maintaining the enormous machines that are used to balance and re-balance rotatives form a substantial part of the cost passed on to customers). In the case of the washing machine, the out-of-balance problem exists from day one since the manufacturer has no control over the loads of washing that are inserted into the machine. The compromise generally adopted in this situation involves the addition of large masses of concrete into the machine in order to ensure that it remains fixed in one place on the ground during high-speed spin cycles with large out-of-balance loads. While concrete is not in itself expensive, transporting it to customers and problems of handling installation often can be. As far as car wheel balancing is concerned, the compromises exist on the car (the need for unsightly lead weights attached to the wheel), at the garage (where there is a need for expensive equipment to balance wheels) and at the manufacturer (which has to make several subtle but nevertheless important compromises when designing the car to be able to operate reliably over prolonged periods when things might be out-of-balance).

All of these problems would disappear, of course, if the rotating assembly was able to balance 'itself'. As it happens, several inventors have developed self-balancing solutions. Unfortunately, very few of their solutions have made the shift from where they were developed to other sectors. Figure 1, for example, shows a patent that was granted over ten

years ago. Although it is in itself a comparatively complex solution to the problem, it nevertheless serves to illustrate a general concept that can quite readily be transferred to other sectors. The patent relates to a device for delivering self-balancing properties to a car wheel. The basic principle contained in the invention is that a rotating part of the system (component 2 in the figure) is designed to contain other parts that are able to move relative to the first part (component 4 in the figure – actually in this case ball-bearings). The self-balancing capability is produced when the ball-bearing components move relative to the main rotating component in such a way that they naturally position themselves to counter any out-of-balance forces. Reference 2 contains a neat description of how the Smart Little People tool can be used to model and describe the action of the ball-bearings for those interested in



finding out more.

Figure 1: Typical Self-Balancing Rotative System

As suggested, the Figure 1 solution is actually rather more complicated than it needs to be – containing not only ball-bearings, but also a damping fluid, and indeed the whole ring component (2) is something added to a wheel rather than using an existing resource on the conventional wheel. Some readers may in fact be familiar with a much more simple solution to this self-balancing wheel problem – a handful of sand thrown into the cavity inside the tyre produces precisely the same effect with no adverse consequences. (Apart from being more difficult to sell commercially!)

The points of this case study are first to register the fact that because balancing is traditionally such a problem area, it is highly likely that there will be someone who will have thought about self-balancing (as it happens, as long ago as the early 1970s as far as the patent record is concerned). Second is the need to register the fact that the elegant self-balancing concept hinted at in the Figure – enable small unconstrained things to move, position and re-position themselves relative to a bigger rotating thing – can be applied in many design situations.

Case Study 2 – Self Seeking

In a somewhat different form, this case study is one that we were involved with on the behalf of a client. The problem being tackled involved the reduction of wasted product produced by aerosol sprays. An extreme version of the problem may be seen when we consider the use of aerosols to kill flying insects. In this scenario, the wastage problem is extreme because insects are small and can move quickly relative to the operator of the spray. As suggested by Figure 2, it is not unusual in this situation for 90-99% of the product to fail to make contact with the insect.

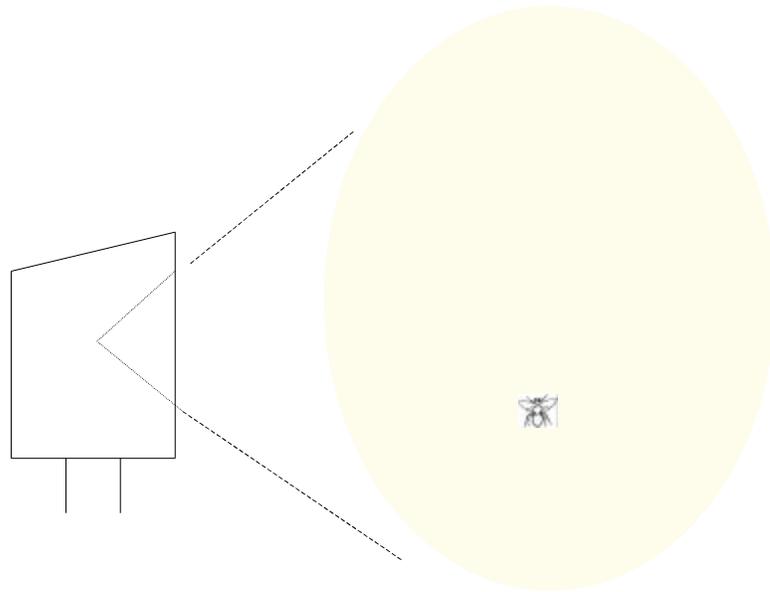


Figure 2: Traditional Insect Spray Situation

In order to help improve the situation, we applied the Ideal Final Result concept to the aerosol spray (alas the constraints of the problem prevented us from looking at solutions that did not involve an aerosol – that being another story). The first thing suggested by the IFR thinking was the concept suggested in Figure 3.

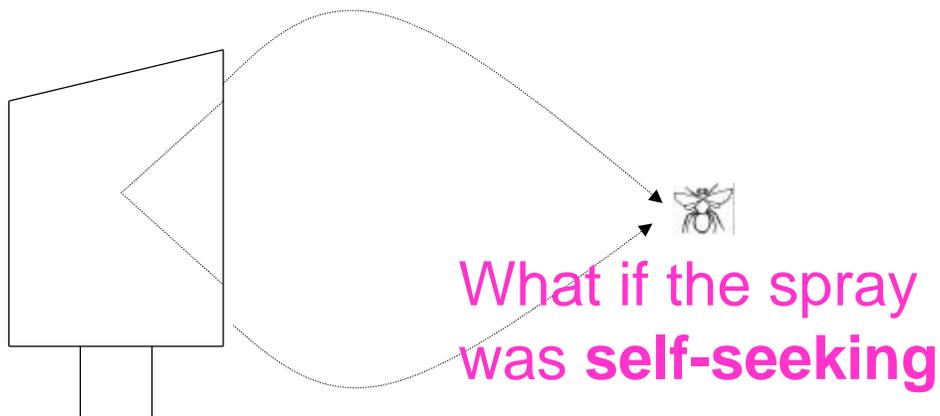


Figure 3: Conceptual 'Solution' To Self-Seeking Insect Spray Problem

To be perfectly honest, the concept sounded quite ridiculous. Nevertheless, we used the suggestion as the basis of a search of some of the on-line patent databases. It didn't take long from that point until we found US patent 6,199,766 granted to inventors at the University of Southampton in March 2001 – Figure 4. The precise details of the invention are not important in the context of this article (as it happens there is an extremely elegant and TRIZ-like use of additional holes in the nozzle design that enables the spray particles to become electrostatically charged as they exit the nozzle), what is important is that even a situation like this where the idea of self-seeking sounded ridiculous, someone somewhere had been thinking in precisely that direction already. Someone somewhere, in general has already been thinking about even quite obscure self-x problems.

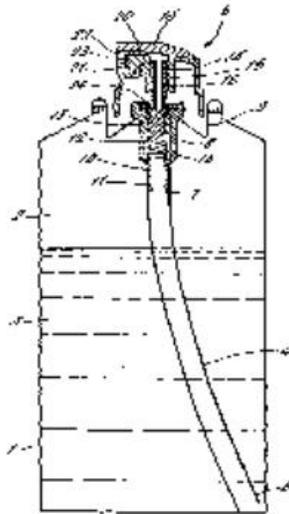


Figure 4: US6,199,766 'Targeting of Flying Insects with Insecticides and Apparatus for Charging Liquids'

For those readers interested in a more complete explanation of what is happening in this self-seeking problem, it is one that sits nicely in the realms of the s-field part of TRIZ: The initial situation in the problem is that we have two substances – an insect and an aerosol particle – with an insufficient action between them. The desired situation is that we deliver a useful function 'particle hits insect'. The s-field rule for delivering a useful function is that the system must contain a minimum of two substances and a field. In the initial situation, the field is missing. Hence, to deliver the required function, a field needs to be added to the system. In order to determine what type of field is likely to be most suitable, it is useful to identify possible field resources present in the system. The existing (but previously unused) field identified by the inventors of US6,199,766 was that the action of flapping wings on an insect result in the generation of certain electrostatic charges. 'All' that was required, therefore to achieve the 'self-seeking' function was to generate a particle with an opposite and therefore attracting charge. Figure 5 summarises the problem in its s-field form.

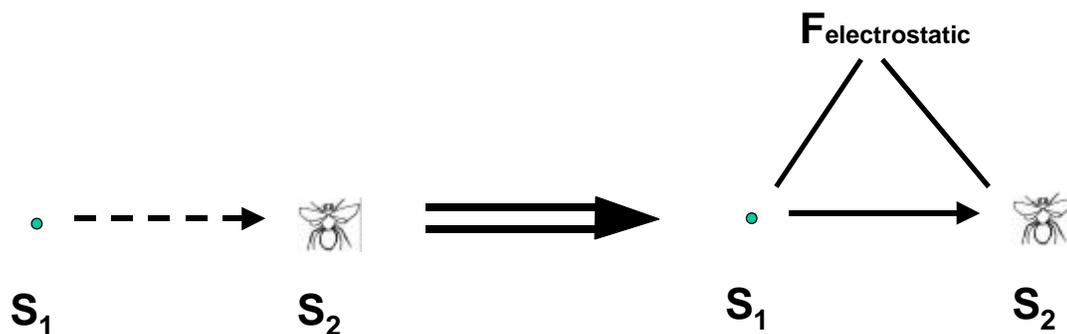


Figure 5: The Insect Spray Problem as an S-Field Problem

The general lessons to be drawn from this case study, we believe, are the close link between existing resources and ideality, and- probably more important here – the need for faith that even a ridiculous sounding self-x example can still produce some valuable solution opportunities. The specific example here is about aerosol particles and insects. On a more general level, the initial situation defined in Figure 5 is one present in situations involving aerosols and small particulates of many types.

Case Study 3 – Self Heating

Taking the use of resources a step further, the self-heating food and beverage containers of Ontro (Reference 3) are well known in the TRIZ community. The Ontro system uses an exothermic chemical reaction involving CaO, but the basic concept of enabling food to heat (or for that matter cool) itself has been around in some form since the 1920s. Another current system (Figure 6) – developed for use by troops during Desert Storm – utilises a different chemical reaction, this time involving a combination of food grade iron and magnesium. When you add water to the pouch – the heater creates a reaction, which releases enough heat to warm-up a pre-cooked meal.



Figure 6: Self-Heating Food System From Zestotherm

While it might be argued that all of these self-heating food solutions – where we have added things to the basic food container – are not genuinely ‘ideal’ interpretations of the self-x systems we have thus far defined, we include them here because they make use of low-cost and readily available resources. In these situations, the fact that the system is actually more complicated is largely irrelevant since the cost (and harm – all of the commercial systems are readily amenable to environmentally friendly recycling or disposal) has not become worse.

Check-lists of low cost and readily available resources are thus useful complements when thinking about ideality and self-x systems.

Case Study 4 – Self Adapting

Manufacturers of clothing or footwear for humans traditionally force the consumer to make a broad range of compromises in order to be able to use mass-manufacture techniques that will keep prices at an affordable level. Every human is slightly different from every other and so what is right for one person is unlikely to also be precisely right for another. This type of compromise problem is traditionally solved by manufacturing goods in a range of sizes, fits and styles. Such solutions present further trade-offs in terms of product inventory versus being able to offer customers as many options as possible. In terms of footwear, despite the possibility of a vast combination of size and width fittings, shoe wearers are nevertheless still faced with the need to compromise on some aspect of the shoe they buy. Not least of which is the fact that over the course of a typical day, our feet can change shape by one or two-sizes. The footwear industry typically forces consumers into trade-off choices like ‘size 9 or size 10’. Or, if it’s an expensive shoe, maybe also a 9½ - another compromise. In TRIZ terms, this is a trade-off that could be avoided if the shoe was ‘size 9 **and** size 10’. This contradiction could be solved if the footwear was able to adapt to become whatever size was

required at any given time. Even better would be a design in which the footwear itself was able to adapt to suit the local requirement.

This kind of self-adapting footwear – if it could be achieved – would not only solve the inventory problems that play a dominant role in the industry, but also deliver customers a product that not only fit better, but also fitted equally well as the shape of the foot changes. It transpires (of course!) that someone has again been thinking about these problems with a mindset that seeks to eliminate the compromises. The slipper illustrated in Figure 7, for example, contains rheopexic gels that cause the slipper to mould (and re-mould) to the changing shape of the foot of the user.



Figure 7: Self-Adapting Slipper (Reference 4)

This case study is a relatively simple, albeit important one from the perspective of adaptive systems and the idea of mass-customization (Reference 5). The principle learning point that the case offers is the importance of effects like the rheopexic gel that deliver adaptive capabilities to systems. Here, the knowledge classification elements of the TRIZ toolkit are extremely important in enabling users to identify systems capable of delivering self-adapting and other self-x functions.

Case Study 5 – Self Drilling

This case study comes from an agricultural application involved in the commercial planting of seeds. Normally, the big problem involved in planting seeds is that they need to be underground before they will germinate, and therefore the planting process involves drilling holes, dropping seeds into those holes and then covering the holes over. The inventors of a soon-to-be-commercialised solution decided that a much more effective planting system would be produced if the seeds were able to drill the holes ‘by themselves’.

A schematic of the resulting self-drilling seed solution is illustrated in Figure 8 below. Seeds are centrifuged off a simple, low-cost, high-speed rotating drum (not shown) and projected towards the ground at a speed of around 400m/s.

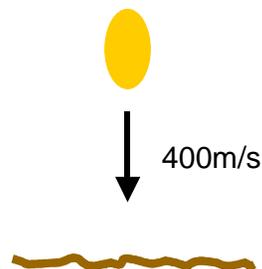


Figure 8: Self-Drilling Seeds – Conceptual Solution

If you’re thinking that this system looks set to do nothing other than destroy seeds, you are wrong. You are wrong because the system as drawn in the figure contains a resource that protects the seed, enabling a totally normal, totally unmodified seed to plant itself. The resource? The resource turns out to be the 400m/s velocity. 400m/s is supersonic.

Supersonic projectiles in air form a shock-wave ahead of themselves as they travel, and it is in fact this shock-wave – rather than the seed – that drills the hole.

The point that this case study teaches us is that the attributes of things within a system can also become resources capable of helping to deliver the desired self-x function.

Case Study 6 – Self Repairing

As systems begin to evolve to take on progressively more of the functions that natural systems are capable of delivering 'by themselves', we are beginning to see the emergence of man-made systems taking on the self-repairing function. Several organizations have recognized the potential importance of material systems capable of repairing themselves, and several appear on the edge of commercial viability for certain high value applications. Close to the top of the list in terms of capability in this area seem to be the University of Illinois at Urbana Champaign (Reference 6). Researchers at the University have developed a new material they say is capable of healing itself in much the same fashion as a biological organism. The focus of their work has been longer-lasting and structurally self-repairing planes, bridges, buildings and prosthetic devices. The Illinois system is conceived around the use of hollow (definitely a good thing to do from a TRIZ evolution perspective!) composite material containing densely packed capsules. Each is filled with a chemical agent that automatically heals the surrounding material when released. The agent is trying to mimic what the human body does quite naturally, albeit thus far in just one small sense at this point in time.

Composites are increasingly ubiquitous in the world around us, appearing in airplanes, sporting equipment, microelectronics and even some types of dinnerware. Yet despite their unique properties, composites often crack if exposed to enough heat or pressure. Once a material like fiberglass cracks, the integrity of its structure is compromised, but cracking of the Illinois material causes the hollow capsules contained in the composite (Figure 8) to be released and set to work repairing the crack as soon as it appears. Tests have demonstrated the repaired material capable of regaining about 75 percent of its original strength. The capsules can be thought of as tiny micro-balloons about 100 microns, or 100 millionths of a meter, in diameter. They are filled with monomers, a basic building block from which the composite material itself is made. When the composite degrades, cracks in the material rupture the tiny balloons, releasing the healing monomers. They then mix with special catalysts sprinkled throughout the material, and form polymers that bind to and repair the fractured areas.

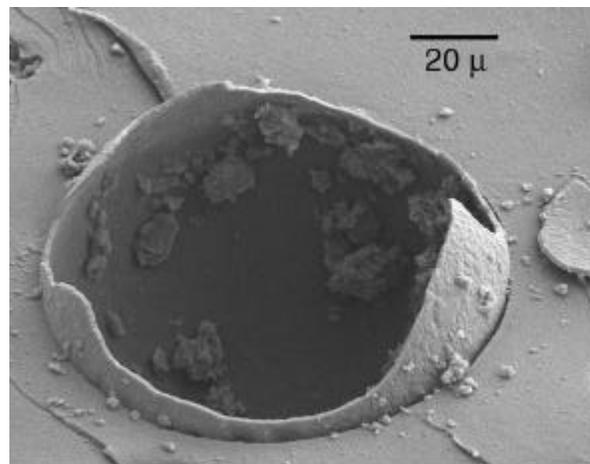


Figure 8: Hollow Capsules of Self-Repair Composite after Fracture and Release of Repairing Monomer

The point behind this case study is not so much the specific solution derived by the University of Illinois (although it is definitely heading in the right direction), but rather a recognition that functions nature has worked out how to achieve in a ‘self’ manner are increasingly likely to be achievable in an engineering context; someone, somewhere has already solved a problem like yours – this time the someone is Mother Nature.

Case Study 7 – Self Creating

Looking perhaps a little further ahead than the self-repair concept is one of enabling systems to ‘create themselves’. In natural terms, such a function is only indirectly achieved through some form of reproduction.

If the idea of self-creating software sounds a little far-fetched, we conducted a short exercise using the CreaTRIZ problem explorer ‘Define Pack’ (Reference 1) to help structure our thinking on the possibilities of such a capability. The results of that exercise are reproduced in Figure 9.

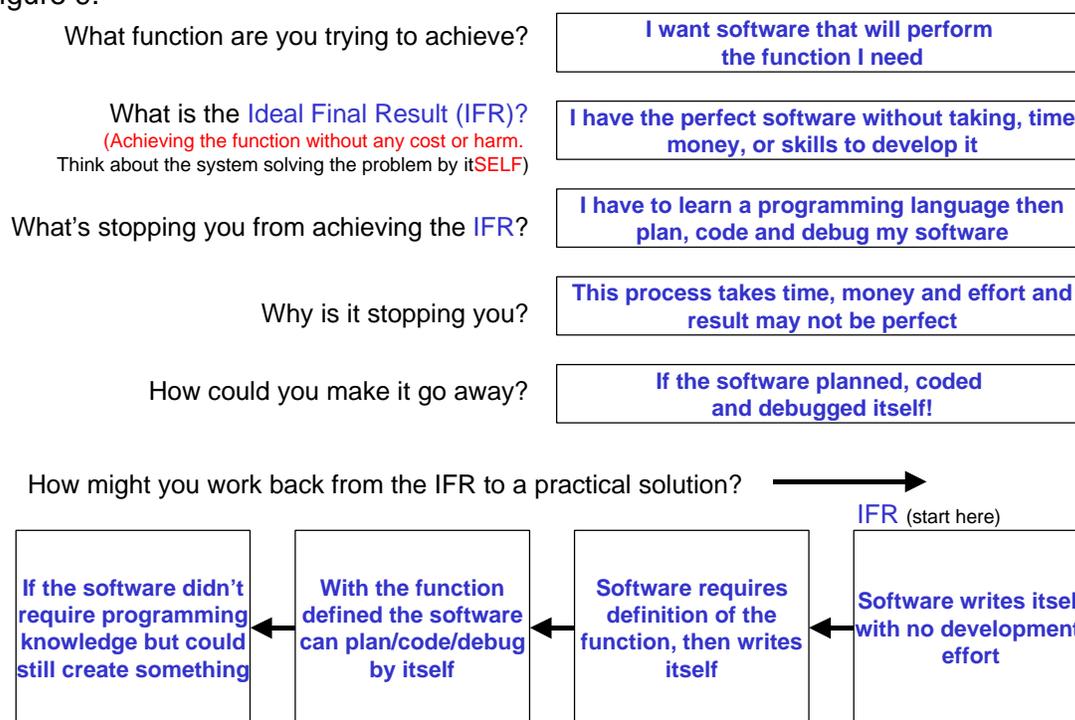


Figure 9: Self-Creating Software

As is usual with this kind of ‘start from the end and work back towards the achievable’ thinking framework, it was useful to think about the viability of the ultimate IFR definition. We soon made a connection to the work of CREAX neighbours, Robonetics, who are trying to make self-generating software systems that will create other software systems. The company specializes in providing tools and services for Artificial Intelligence and Robotics. The recent announcement of their Robot Intelligence Definition Language™ (RIDL™) sees the first release of their self-creating software capability.

Agent-Based Software Engineering tries to model software using agents. To take one simple example, when attempting to model the stock market, one considers a stockbroker as an agent with his own set of goals, and a company with a different set of goals. Putting these together can model the complex interaction of the stock market. Unfortunately, in the past, it required complex software engineering to convert an agent-based design into an object-oriented software design that can be implemented. To make a comparison: not many people

were designing object-oriented databases at a time when only relational database management systems existed. The conversion was just too time consuming. Likewise, agents are rarely used in real life software. RIDL™ is a design specification language that is built from the ground up to create agent-oriented software. Once the design is made in RIDL, code generation will automatically build the software in an object-oriented language. As part of this process, RIDL solves complex issues. Data flows are analyzed to determine the priority of each agent, execution thread reduction is used to keep systems with ten thousands of agents still executable on a single processor computer, and other conversions are performed. The end result is an object-oriented program that can be compiled directly to working code. RIDL™ supports full Agent-Oriented Software Engineering (AOSE), including agent-level polymorphism and inheritance, and support to dynamically create agents in Multi-Agent Systems (MAS). In the language of Robonetics, *'RIDL joins the designed agents into a working society that defines the mind of the computer'*.

The RIDL capability sees complexity 'emerging' from small constituent pieces of software (digital DNA?). In this sense it bears considerable similarity to the messages contained in Reference 8 – ideal self-x systems emerge autopoietically. (Autopoiesis is defined as a network pattern in which the function of each component is to participate in the production or transformation of other components.)

Conclusions

A number of self-x based case studies have been examined. Whether or not we like their specific details, each one has something general to tell us about the importance of 'self' solutions throughout the world of successful innovation:

In the Self-Balancing example, we see the word 'self' as the trigger to solving a number of conflicts and contradictions in the area of systems that rotate.

In the Self-Seeking spray example, we see how the application of the word 'self' in a context that initially sounded quite ridiculous eventually proved to be extremely fruitful. This in a situation where there was barely even a 'system' in its truest TRIZ sense at all prior to the application of the self trigger word.

The Self-Drilling example is similar in the sense of sounding faintly ridiculous when first mentioned, but also makes the additional point about the close connection between ideality and resources – such that even the attributes (in this case velocity) of a thing can be used as resources that can help solve problems.

The Self-Adapting and Self-Heating case studies make clear the similarly strong link between 'self' and the knowledge/effects and resource check-list parts of TRIZ (Reference 1); it is increasingly likely that someone, somewhere has already solved your 'self' problem.

Finally, the last two examples – Self-Repairing and Self-Creating – speculate on the likely impact of systems that begin to take on some of the functions that nature has already mastered on the world and the use of 'self'. These two cases point us in the direction of fully autopoietic systems (Reference 8) and complexity emerging from bottom-up simplicity.

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