Systematic Innovation

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In this month's issue:

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Our guarantee to the subscriber is that the material featured in the e-zine will not be published elsewhere for a period of at least 6 months after a new issue is released.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

Finding The 'Missing' Functions

One of the most important system analysis tools in TRIZ is Function And Attribute Analysis (FAA). One of the most valuable parts of the tool occurs when users are asked to think about the negative elements contained within a system. When we are thinking about these negative elements, we are generally focused on four questions:

- what are the *harmful* relationships in the system?
- what are the relationships that deliver *insufficient* of the desired effect?
- what are the relationships that deliver *excessive* amounts of the desired effect?
- what are the relationships that are *missing*?

The focus of this article is that difficult fourth question. It is the most difficult one on the list because it appears to be so open-ended. The first three all require us to focus on things and relationships that are already present in the system. The 'what's missing' question is fundamentally not. What is inside a system is finite; what is 'missing' sounds like it could be infinite. The aim of the article is thus to demonstrate, firstly, that it is not, and secondly, to discuss ways and means of identifying those 'missing' functions that will offer the best chance of delivering a novel and useful solution.

Finding the (useful) 'missing' functions is a search best done on a number of levels. We will examine two of the important ones in this article; the first looking at the customer, and what the customer might want, and then the second looking at attributes of the system and how the voice of those attributes might help us to identify what might be missing.

1) The (Missing) Voice Of The Customer

Customers are notoriously bad at telling designers what they want, beyond the standard cries for better, faster, cheaper. They are the very worst at telling designers about 'missing' functions. One of the strongest factors that will determine whether one producer will be more successful than another is which one will identify and incorporate these 'missing' functions before the other. Often, these missing function relate to the idea of 'hidden failures'. The classic examples of hidden failures come from things like take-way pizza boxes and digital cameras. Customers lived for ages with the fact that their pizza was going to be cold and soggy when they opened the box, because, hey, that's the way take-away pizzas are. There were hidden failures and missing functions – keep the pizza hot and crispy. With the digital camera, a host of functions 'missing' from film cameras immediately became apparent – from instant viewing, to the ability to edit out the bad photos before printing, to editability, to… the list goes on.

One of the favourite ways of identifying these hidden failures and 'missing functions' is the 'visit the gemba' exhortation of QFD. The only way to hear the voice of the customer is to get out there and be with the customer, experience what the customer experiences in the customer's environment. Great idea. At least in theory. Few companies do it well, however, because it is difficult, expensive and fraught with opportunities to mis-interpret the signals.

Systems of whatever description exist to perform functions. These functions may be tangible ('maintain temperature') or intangible ('bestow social status'), but they are ultimately the reasons why a customer will select one product or service over another.

Hence, a simple and effective way of identifying missing customer functions is to use the TRIZ function database structure as a checklist. TRIZ researchers have done an awful lot of work to try and identify all the different functions that systems are designed to perform. That's a pretty powerful resource when it comes to thinking about what functions a customer might want that they don't currently have.

The main downside of adopting this function check-list approach is that there is a very strong tendency to conclude for any given function that there is no advantage in adding that function to a system. This is another of those dangerous psychological inertia effects. I, for example, would never have thought to ask for a camera on my mobile phone. As recently as three years ago, virtually nobody was even asking the question. A significant 2004 management text was still claiming that camera-phones were a mere passing fad. I've had a camera phone for about a year now, and I'm still finding new functions that it is delivering for me: I'm in a new city and not sure where I am – I take a photo of street names, buildings and other markers and I've solved my 'avoid getting lost' problem. I'm in a big car-park and am not sure how I will find my car – take a photo and I've solved my 'find the car' problem. I'm at a railway station in a strange country where I don't know any of the place names – so I take a photo of the train timetable and there's a reminder of what time the train is supposed to be where and I solve my 'when to get off' problem.

The point being that I look through the function database and see function words like 'orient' and my instinct is to say 'not relevant'. Wrong. The right question is 'why would adding an orient function to a camera be a good thing?'

It would have meant an awful lot of gemba visiting for a handset designer to find those missing functions. As it turns out, they didn't need to; all that was required was to rely on the list of functions contained in the function database and find a way of delivering them.

2) The Voice Of The Attributes

The second 'missing' function location technique is one that starts from examination of the internal attributes of a system. As soon as we shift from the external to the internal, the infinite very quickly turns into the finite. The basis of the following technique is that in addition to the voice of the customer, there is also the voice of the system. Or rather, the voice of the attributes of the system; internal aspects of the system that can help us to identify what is missing from the system.

We will examine the proposed technique at two levels. On the first level, we will focus on the attributes of just one of the elements present in a system. Then, after describing the basic technique on one element, we will expand our horizon and explore how it might work when two or more elements are considered.

Let's start with one element. Figure 1 illustrates such an element and a partial list of its associated attributes. It happens to be a surgical glove in this case, but it could, of course, have been anything.

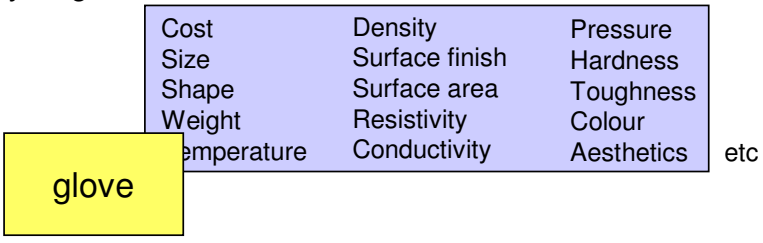

Figure 1: Partial Attribute List Of A System Element

Once this list has been constructed (the CREAX Innovation Suite will do it automatically for us), the 'missing' function part of the process may begin. Essentially, it is as simple as taking pairs of attributes and determining whether there is any functional relationship between those attributes, and if there is not, should there be.

A couple of examples may serve to demonstrate the basic idea:

Firstly let's (randomly) select the size and pressure attributes of the glove. Is there a relationship between size and pressure? Answer; yes – if we increase the pressure inside the glove, then the glove will expand. This sounds like simple physics. So is there a missing relationship between pressure and size? How about reducing pressure outside the glove to make it expand to ease putting it on? Or how about making the size of the glove change if the pressure locally exceeds a certain point? We probably don't have enough knowledge here to now determine whether either of these 'missing' functions are of any value to us, or indeed how we might achieve them. The point, at least as far as this article is concerned, is to demonstrate that by looking at pairs of attributes within the system we can systematically explore missing relationships. Let's try another one:

Figure 2: Examining Pairs Of Attributes Of The Glove

This time let's look at the pressure of the glove and the colour – Figure 2. Is there currently a relationship between pressure and colour is our first question. Answer in this case is, no there is presently no relationship between pressure and colour. So, is there then any benefit in adding a relationship between pressure and colour? i.e. is there a missing relationship between these two attributes? Interesting question. Now it is up to our creativity to try and establish whether there is something useful that we can do to relate pressure to colour. Again, it is not the point of this article to come up with glove innovations, but what seems immediately clear from speculating about the potential benefits of a relationship between pressure and colour is that we could make the colour of the glove change if the pressure on the glove exceeds a certain value. This colour change could then give the wearer a visual indication that, for example, the glove is being excessively stretched, or that it is about to break locally (e.g. be pierced by a medical instrument).

Now let's expand the basic technique to examination of more than one element. In truth, we can (and should) examine any and every pair of elements within a system, but often time limitations will prevent us from doing this. In which case it is useful to know that if we examine pairs of elements where one element is within the system and the other is part of the super-system (e.g. the user), then our search for 'missing' relationships will tend to be more fruitful.

Figure 3 illustrates a partial FAA diagram of a system in which a control unit and the actuator that it controls are the only elements shown. Attributes for each of the two elements are included in the picture. Exactly as was the case for the single element analysis, the 'missing' function location job when we have two or more elements

comprises taking pairs of attributes – one from each element – and asking whether there is a relationship between those attributes, and, if not, whether there might be some kind of advantage in adding one.

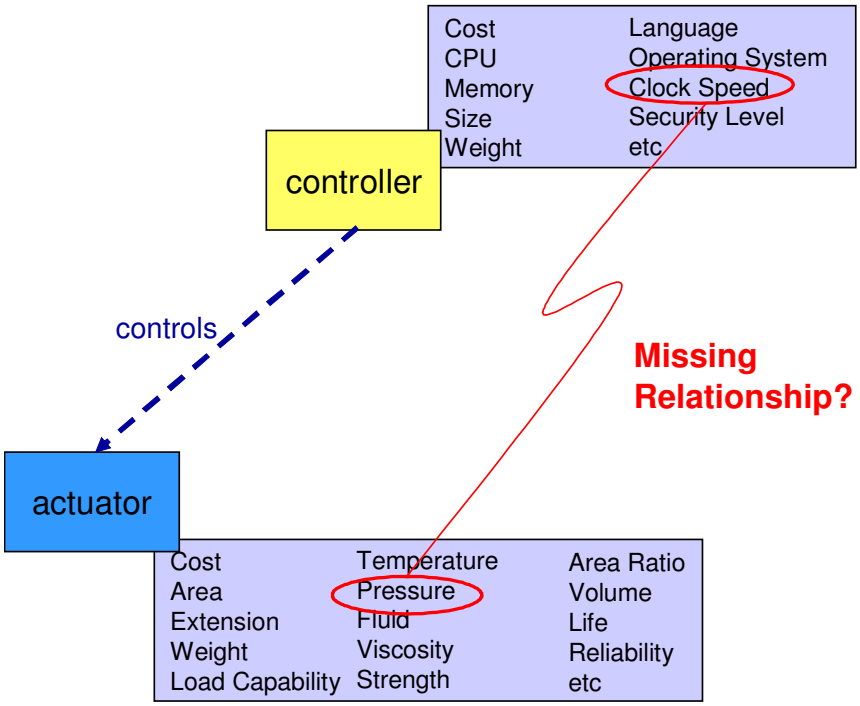

Figure 3: Examining Attributes Pairs Between System Elements

In the figure, an attribute from the controller and one from the actuator have been selected at random. Having made this selection – likely to be the first of many – our job becomes identifying links between the two. If, in this case, we determine that there is currently no functional relationship between the clock speed of the controller and the pressure within the actuator, then the new question becomes, 'is there any advantage in adding a connection between these two attributes?' Is there, in other words, a missing relationship between clock-speed and pressure? Having made the connection, we might speculate that, yes, there is an advantage in making a link between the two – e.g. we might cause the controller clock-speed to alter depending on either the pressure level or (more likely) the rate at which the pressure is changing in the actuator.

Again, the point is not about the specific links made here but the overall process of using attribute lists as a means of identifying potential 'missing' relationships within and around a system.

Summary

What we have seen in this article is a pair of techniques to help to systematically locate potential 'missing' functions, and thus help to deliver innovative new solutions. One of the techniques is external and the other internal to the system; one relates to the voice of the customer; the other to the voice of the product. Both are necessary if we are to derive the strongest possible solutions. The external (voice of the customer) technique involves use of a function database as a checklist for identifying what functions might usefully be added to a system. The internal (voice of the product) technique involves examination of pairs of

attributes of either individual or multiple elements within a system in order to find whether there may be any benefit in making a functional link between those attributes.

The techniques are not the whole of the ‘missing function’ story (more about other techniques in future articles), but they form a significant foundation, upon which strong innovative solutions can be built.

TRIZ And Stage-Gates

What is the easiest way to introduce TRIZ (or any other methodology come to that) into an organization? This article is about a simple and highly effective technique. So simple, in fact, that almost no organization in the world has done it. As we shall see very shortly, despite the simplicity of the technique, it is not without its problems. We will first of all examine the technique, and then end by examining how we might overcome some of the problems that might emerge as we try to implement it.

Stage Gate Processes

Most organizations these days have created some kind of process for managing the innovation process. Such processes take on many different forms. Figure 1 illustrates a typical one. An aspect common to the vast majority of all of the forms is the use of stage-gate reviews at certain critical points through the activities required to deliver the final innovation.

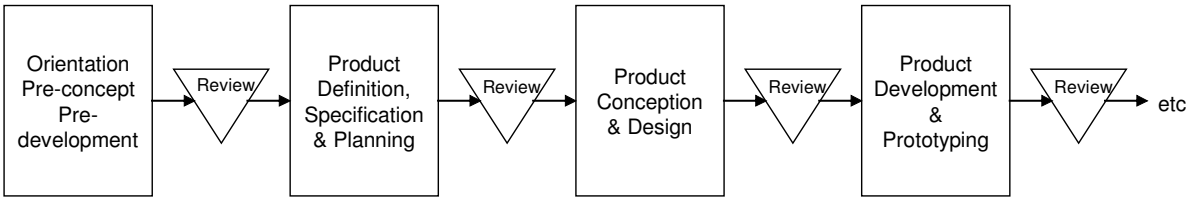

Figure 1: Typical Product/Service Development Process

Each of those stage gate reviews represents an opportunity for management to review and assess the work done by the project team. Typically, the reviews have a pre-defined protocol and series of questions that the project team have to present answers for. At the preliminary design review gate, for example, there are likely to be such questions as:

- has a patent review been conducted?
- Have patent applications been filed?
- Has a risk assessment been performed?
- Has an investment appraisal been done?

How about if we now add to this kind of list questions like:

- Has a function and attribute analysis been conducted?
- Has a Contradiction analysis been conducted?
- What conflicts and trade-offs have been challenged?
- Has an Evolution Potential analysis been conducted?
- What untapped potential has been exploited in this project?
- Has a resource analysis been conducted?
- Has a constraint analysis been conducted? (What constraints have been challenged?)

Adding these types of questions is undoubtedly easy for those managing the process; all that is really required of them is a recognition that the questions (and their answers) are important elements that will determine the likely commercial success of the project. Thus,

referring to an earlier article (July 04) concerned with ‘pleasure-seeking’ and pain-avoidance’, from the manager’s perspective, adding these questions to each review process is all gain and little or no pain.

The story is a little different for the people being reviewed of course, since being required to know how to answer the questions in turn requires that they know something about TRIZ. This may not be such a problem since a very large proportion of the problems we see with TRIZ deployment in organizations occurs not at the working level, but at the management level; how many people reading this have been prevented from doing what they wanted with TRIZ because of a lack of management support or time?

So how about this for a radical thought, for those interested in TRIZ that are having difficulty getting integrated into their company; how about suggesting to project/process managers to include some of the questions in their reviews? Start being pro-active about TRIZ deployment, but in a very simple, no-pain manner. At the very least, suggesting to managers that projects should be reviewed in relation to things like contradiction analyses is a neat, unthreatening way to get them to think about why TRIZ might be important in the innovation story.

The point here is that to get TRIZ (or, again, any other method) introduced into an organization requires a pathway in which there are only winners. If the method comes across with any kind of negative connection then the ‘plausible deniability’ phenomenon comes into play – anyone in a position of authority that has any kind of plausible reason with which to justify to their superiors why something wasn’t done is likely to use that reason to make sure that the thing doesn’t get done.

Not So Funny – Bad Designs Of The World Part 129 – Cat Litter Packaging

It's been a strange old time at home in recent weeks. A girlfriend recovering from an operation has meant I got to do a whole bunch of jobs that I never normally have to. Like emptying the cat litter tray. And filling it up again with new litter.

Initial attempts to solve the latter problem focused immediately on the root causes. The tray needs to be filled because spent-litter has to be removed; litter has to be removed because the cats 'use it'. The cats use it because, hey, they're cats. Root cause equals cat. Alas, however, the cats were not inclined to want to do what they have to do outside in the middle of winter, and so yet another root cause analysis session went sadly to waste. Excuse the pun.

Instead, then, the problem focused on the opening of new bags of litter:

'Easy open' litter no less. Simply pull the top tape right to left and, hey presto, ankle deep in exploding bags. Or at least that was what I imagined would have happened had I actually had the strength required to pull the top tape. Insert image of eyeballs bulging at the exertion of trying to pull this apparently Kevlar-constructed tape from right to left.

As can be seen from the picture, the only thing to do in the end was perhaps what could have made life simpler for everyone; scissors. Perhaps all of the world's cat litter designers are body-builders? Or maybe they are not allowed to use sharp objects? For whatever reason, their solution is rubbish. It is expensive, difficult to manufacture, and it annoys the (this) customer. Zero out of three. Congratulations.

I have sent the company a drawing of a pair of scissors to perhaps give them a clue as to how they might re-examine their design in the future.

In the meantime, I'm working on a bag opening containing cat-nip so that the cats can open the damn bag themselves in future.

Patent of the Month

Patent of the month award this month goes to IBM:

United States Patent **6,835,973**

Daubenspeck , et al. **December 28, 2004**

Antifuse for use with low .kappa. dielectric foam insulators

Abstract

A fusible link for a semiconductor device comprises an insulating substrate and a conductive line pair on the surface of the insulating substrate, with the conductive line pair having spaced ends. A polymer is disposed over the insulating substrate and between the conductive line pair ends. The polymer is capable of being changed from a non-conductive to a conductive state upon exposure to an energy beam. Preferably, the polymer comprises a polyimide, more preferably, a polymer/onium salt mixture, most preferably, a polyaniline polymer doped with a triphenylsufonium salt. The link may further comprise a low .kappa. nanopore/nanofoam dielectric material adjacent the conductive line ends.

The patent involves a classic physical contradiction situation: we want a fuse AND we don't want a fuse. Fuses are used in integrated circuit devices such as semiconductor chips to provide redundancy, electrical chip identification and customization of function. For designs having three or more layers of wiring, the fuses are typically formed from a segment of one of the wiring layers, e.g., the "last metal" or "last metal minus one" wiring layer. Fusing, i.e., deletion of a segment of metal fuse line, is accomplished by exposing the segment to a short, high intensity pulse of "light" from an infra-red laser. The molten metal then boils, vaporizes or explodes out of its oxide surroundings, disrupting line continuity and causing high electrical resistance.

One of the biggest issues associated with blowing fuses is that the dielectric surrounding the fuse must act much like a pressure vessel, i.e., holding the fuse captive until sufficient pressure is achieved during the superheating phase to cause the fuse link to explode through the weakest wall of the pressure vessel and instantaneously boil away. If pressure is released too soon, the fuse melts and extrudes to the surface through the cracks in the dielectric. Any porous materials in contact with the fuse link will experience compression of the voids with subsequent loss of pressure. It is therefore desirable to create a solution in which there is no need to physically blow fuses.

The IBM invention avoids the need by utilizing polymers that can be made to become conductive upon exposure to a laser or other energy source, e.g., ion beam. The described structure allows formation of fuses with either polymer or glass low .kappa. dielectric films with minimum impact to the dielectric structure. The invention provides a fuse structure that is compatible with nanopore/nanofoam low dielectric constant insulating films required for advanced integrated circuit devices. Because the fusing metaphor is changed from deleting a segment of metal line via a localized explosion to causing a local change in the conductivity of a film in contact with the metal lines, mechanically fragile and porous insulator films can be used.

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As such, the IBM solution makes use of both Principle 35, Parameter Changes and Principle 28, Mechanics Substitution (seen in the introduction of the laser or ion beam source).

Both of these Principles feature in the ‘Separate on Condition’ classification of physical contradiction solution strategies. Along with the ‘Alternative means’ classification, ‘separate on condition’ tends to offer solutions that are much stronger than those provided by the separate in space or time categories.

Probably more important in this case is the fact that the solutions created by the IBM inventors required the combination of the Parameter Change AND the introduction of the field – each on its own would not give the desired effect. A useful general point, then, arising from this invention is the importance of not rejecting ideas too soon. We have no way of knowing what went through the minds of the inventors during the critical moments where the inventive step was first realized, but we do know for sure that it never included the moment where someone suggested ‘use a material that changes conductivity’ and someone else aid ‘yes, but….’

Best of the Month – Keith Jarrett: The Art Of Improvisation

A television programme rather than a book or article acts as the focus of our best of the month feature this month. The programme in question is likely to be available on a cable or satellite channel near you, or if not, it should be out on a video/DVD in coming months.

The programme centred around jazz and classical pianist, Keith Jarrett. For those readers who have never heard of Keith Jarrett, he is almost unique amongst musicians in that he is able to give concert-length performances of solo piano that are completely improvised. The fascination from the creativity perspective, is that here is someone capable of being successfully creative on the fly; no rehearsal, no opportunity to assess and correct, just pure creativity.

Amongst a number of valuable insights into the process of improvisation was the following interview:

Interviewer: *How important are other things than music in influencing the way you think?..*

KJ: *More important than music.*

Interviewer: *…like writing, philosophy?*

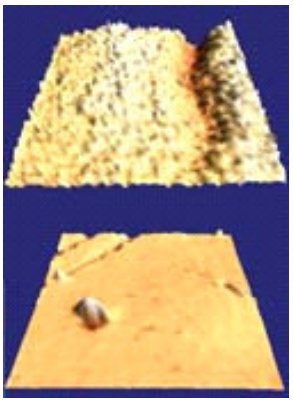
KJ: *More important than music.*

Interviewer: *Really?*

KJ: *Yes. One of the biggest fallacies I think in art circles and in music circles maybe when people talk about it is that music comes from music. It's like saying baby's come from babies. It's not true. It isn't what happens. Music is the result of a process that a musician's going through especially if he's creating it on the spot.*

Investments – Polymer Magnets

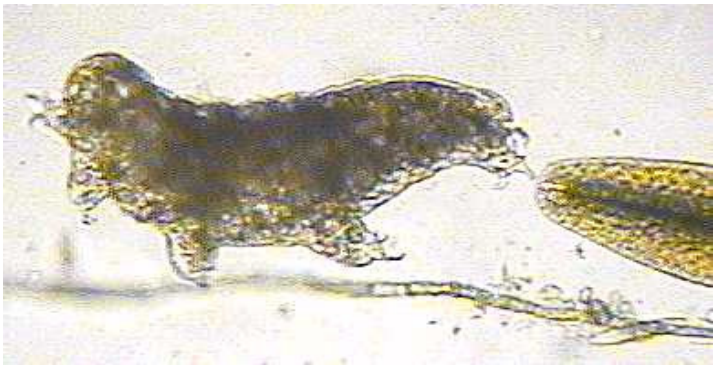
Researchers at the University of Durham have (kind of accidentally) succeeded in developing a polymer that is magnetic at room temperature. Use of a polymer rather than a metallic material is expected to confer a number of benefits in terms of density, form-ability, bio-compatibility and cost. Various applications, including computer hard disc coatings and implanted human prosthetics have been cited.



For more information on this world first, contact Dr Naveed Zaidi in the university's Department of Physics.

Biology – Tardigrades

Tardigrades, which are more commonly known as "water bears" because of their bulky appearance under a microscope, can survive pressures, temperatures and radiation exposure that quickly kill all other animals. In their active state, tardigrades walk around on eight stumpy legs looking for food and are covered in what appears to be armoured plates. Tardigrades can survive pressures that are 6,000 times greater than sea-level barometer readings – more than twice the pressure that destroys the vast majority of the most rugged bacteria. The capacity of tardigrades to survive extreme conditions is renowned. Some have been revived after lying dormant for more than 100 years in the dried moss collections of museums. Their extreme hardiness is due to their ability to undergo complete dehydration,
where they entirely lose their body fluids and survive in low-oxygen conditions without ill-effects. "Terrestrial tardigrades become immobile and shrink into a form known as the 'tun' state when the humidity decreases," said Kunihiro Seki and Masato Toyoshima, from Kanagawa University. "In this state they can survive extreme temperatures, as low as minus 253C or as high as 151C, as well as exposure to a vacuum or to X-rays." The scientists subjected the tardigrades in their active and dehydrated states to a range of very high pressures for 20 minutes at a time, using a special fluid called perfluorocarbon to prevent the tun tardigrades from rehydrating. They found the dehydrated tardigrades could survive pressures three times higher than the pressure which killed the active forms of the animal. Understanding how the tardigrade is able to survive extremes of humidity, pressure and temperature may help to develop new preservation methods, such as long-term storage of human organs for transplant operations, the Japanese scientists said.



The precise mechanisms by which the Tardigrade is able to withstand such extremes are not yet fully understood, but clearly there are elements consistent with Inventive Principle 35, Parameter Changes. The new Contradiction Matrix tends to suggest that scientists and engineers seeking to solve similar problems have used the same strategy:

Improving Factor	Worsening Factor	Principles
Stability (21)	Stress/Pressure (19)	40 3 35 31 18 2 13 4
Tardigrades are required to survive extremes of pressure		
Stability (21)	Temperature (22)	35 40 3 1 24 18
Tardigrades are required to survive extremes of temperature		

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