

Elements of safety culture, such as leadership versus communications, could be acted on in order of priority by the level of safety culture maturity they were found to be at. Qualitative understanding of the drivers for behaviour can help identify specific improvement actions.

It is also important to identify the stronger areas identified through assessment as this provides lessons learned that can be applied to other departments or other elements. Creating a strategy for improvement will provide direction to address problems and build on the strengths of safety culture in your organisation.

## Reassessment

Safety culture should be periodically reviewed to check performance and the effectiveness of any actions coming out of the safety culture assessment. Some safety critical organisations assess safety culture every year, comparing trends from one year to the next.

In our experience, the extent and frequency of assessment depends on the level of safety culture maturity and the need for improvement. A more mature and possibly stable, culture may not require annual review or in-depth assessment. A less mature culture, or one with a major improvement programme, might benefit from more frequent and more in-depth reassessment.

## References

[1] J. Baker et al, *The BP U.S. Refineries Independent Safety Review Panel*, January 2007. [http://www.csb.gov/assets/1/19/Baker\\_panel\\_report1.pdf](http://www.csb.gov/assets/1/19/Baker_panel_report1.pdf). Accessed December 2016.

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# Let Me Make Myself Unclear

by John Ridgway

One of the very first books I read as a child (apart from the 'Janet and John' books) was a volume proudly retrieved from the local library. It was called *How Big is Big?* and it sought to demonstrate mankind's scale within the Universe by illustrating a series of objects of ever-increasing size (firstly terrestrial, then extra-terrestrial), finally arriving at the Universe in its totality. It then proceeded to illustrate objects of ever-decreasing size, culminating in the sub-atomic realm. It remains to this day the most influential book I have ever read and, no doubt, set me on a lifetime of scientific curiosity. However, despite my advancing years, I have to admit that I still can't answer the basic question posed by that influential tome. I still can't tell you how big 'big' is.

The problem lies not in my education, but in the inherent vagueness of the term 'big'. It's one of a very large class of words known as degree adjectives. All natural languages are full of them. In fact, most languages would be a pale shadow of themselves if one were to remove all the inherently



vague words from their lexicon. Furthermore, the majority of early words learnt by a child will fall into the category of 'vague' ('Mammy' and 'Daddy' are notable exceptions). Despite all of this, however, the word 'vague' is seen very much as a pejorative term, particularly in the hard-nosed world of high-integrity systems development. So how can it be that words that have such an undeniable ubiquity and (presumably) linguistic merit should be treated as swear words when it comes to developing safety cases?

In this article, I propose to have some fun by challenging the obvious notion that all vagueness is bad. I would also question the assumption that the alternative should be any better. But firstly, to avoid the embarrassment of writing a vague article on the subject of vagueness, I need to define my terms.

### **What Precisely is Vagueness?**

According to the dictionary, 'vague' is an adjective used to describe words and language that are inexact or imprecise in meaning. However, here I wish to use the term in a more narrow and technical sense. There are a number of ways in which one may be imprecise but the one that interests philosophers of vagueness (yes they do exist) is the imprecision that results

from using expressions that have borderline cases, i.e. marginal cases for which the expression's applicability is unclear (see note 1). These problems will be inherent within the expression being used. One may try to resolve the difficulties by introducing a defined boundary but this will have two implications. Firstly, the expression is no longer being used in the general sense required by its definition. Secondly, it is still necessary to deal with paradoxes that arise at the threshold you have defined.

For example, the term 'warm' is vague because it is not clear just where 'cool' ends and 'warm' begins. In an attempt to introduce clarity, one might agree that 18°C (or above) constitutes 'warm' but the expression 'warm day' would now be potentially ambiguous: if others choose to define the threshold differently, one would have to be sure which definition was being used. Furthermore, the applicability of the term 'warm' will always be context-specific – what might be a cool summer's day could be considered warm for winter. Besides which, arbitrary thresholds are rarely realistic. If the actual temperature were fluctuating slightly about the threshold, one would be unlikely to refer to the weather as vacillating rapidly between warm and cool.

Worse still, one would now have an expression that is susceptible to the sorites paradox. This paradox gets its name from the word 'soros', which is the Greek for 'heap' or 'pile', and it originally alluded to the difficulty one has in determining exactly when a pile of sand ceases to be a pile as one removes its grains. The problem stems from the vagueness of the word 'pile' and the lack of a convincing cut-off.

To fully appreciate the significance of the paradox, consider the following example: If 10°C is defined as 'cool' then a temperature in excess of 10°C must also be considered cool if it is practically indistinguishable from it. By the same logic, any temperature that exceeds this new temperature, and is practically indistinguishable from it, will also qualify as being cool. And so on – one can repeat the process any number of times to any arbitrarily high temperature, and yet still require that the temperature be defined as 'cool'. This can't be right. It's like the frog which, placed in a pan of cold water, boils to death because it cannot perceive a gradual rise in temperature (see note 2).

It is because of all of the

above that linguists worry about adjectival vagueness. However, I should point out that adjectives do not hold the monopoly, since vagueness can also be encountered when dealing with nouns. For example, when I'm driving on the motorway, I am never quite sure if I have just been dangerously cut up by a lorry or a van. Where does 'van' end and 'lorry' start? Here, the question is the extent to which an object exemplifies a particular quality, such as 'lorryness'. In the real world, things are often not clear-cut and one has to accept degrees of truth.

### **The Acceptable Face of Vagueness**

A number of philosophical theories have been developed in an attempt to address such problems but we needn't go into them here (see note 3). I suspect you won't find them of too much help when writing your safety case or deciding upon your safety policies. I do, however, think that, despite these problems, it would be wise to reflect upon the benefits of vague expressions before you assign them to Room 101. We need to ask whether there are times when you would be better off remaining vague, and whether the cure can be worse than the disease. To address these matters I will need to subject-hop for a while, so please bear

with me.

### **Promoting Reusability**

One of the problems with vague expressions is that their applicability changes depending upon context. But actually, that is the main reason why they are popular – they have semantic utility. And, to the extent that re-usability is a positive feature for safety case elements, one may be looking for expressions that have such utility.

Take, for example, the term 'reliable'. This is a vague term because it allows for borderline cases and its precise meaning will change with circumstance. However, this allows it to be used in a variety of contexts whilst still retaining its transcendent meaning, i.e. 'dependable enough for purpose'. An adaptable safety case element can therefore be constructed using this term, as long as one is prepared to validate the anticipated failure rate within the context of each of the safety case element's instantiations. For example, one can construct a generic argument for the safety of a utility component by providing evidence for its predicted failure rate and then claiming that the component is therefore 'reliable'. This argument necessarily remains vague until the case element is placed within the context of a particular system's safety case, i.e. once

the application-specific requirements and design context have been taken into account.

### **Reducing Pointless Detail**

Then there is the *maxim of quantity*, which requires that statements should be as informative as possible whilst being no more informative than is necessary. By this maxim, vagueness is allowed as long as it isn't gratuitous, and tackling vagueness by being more precise than is required (or justified) is the worst thing you can do. For example, we engineers love numbers and, as soon as we see them, we breathe a sigh of relief. No more naughty vagueness, we declare, whilst quietly overlooking the need for error bars. But we give numbers far too much credit, often quoting decimal places just because our calculator produced them.

And whilst we are talking about numbers, remember that quantified thresholds can still boil your frog. If 1000 Killed or Seriously Injured (KSI) is tolerable, then why not 1001? And if 1001, why not 1002? You may think you can tame the vagueness with numbers and limits, but this is all part of the illusion.

### **Handling Subjectivity**

This brings me onto the

unquantifiable. Don't go pretending that it doesn't exist. It is all around us and its assessment is always problematic, rendering the use of vague expressions all but inevitable. Thankfully, that's what we have experts for. Most vagueness in safety cases is hiding behind the over-confident proclamations of a revered expert.

Vague expressions are also popular because they can convey an opinion. The terms 'acceptable' and 'safe' come to mind. We can use specific targets, such as '100 KSI', but the targets mean nothing until they are equated with the expression 'acceptably safe'. The problem here is not so much the vagueness; it is the fact that opinions can differ.

### ***Avoiding the Arbitrary***

Another major benefit of vagueness is that it avoids the tyranny of the arbitrary cut-off. Take, for example, the definition for KSI. In order to have been killed, one has to have died within 30 days of the accident. So, presumably, if you die just one minute later then you were not killed. The conditions required to qualify as 'seriously injured', on the other hand, are not as clear-cut; which is perhaps a good thing.

### ***Legislating***

Vagueness will often

be deliberately written into legislation, thereby requiring someone to interpret the application of the law in test cases. Here, again, the vagueness is being used to bestow utility. The classic example within safety legislation is the concept of reasonably practicable. It seems we expect our judges to know how big 'big' is, and we are expected to be able to second-guess them. In fact, the ALARP principle doesn't just tolerate vagueness. It virtually worships it.

### ***Hedging Your Bets***

Last, but not least, no one wants to be caught out making bold predictions that Nature then disrespects, so why not make a vague claim that will be easier to defend with hindsight? After all, you are just offering a lower Safety Assurance Level (SAL), aren't you? But what if there is so much riding upon the acceptance of the safety case that you just slip in the odd vague term in the hope that no one notices? Or was that just me?

### ***Utility Versus Precision***

There are some who view vagueness in language as a linguistic anachronism - a legacy of our primitive past, when sophistication and precision provided little evolutionary advantage. I disagree. Our love of vague terms is not a failure to divest ourselves of a bad

habit. On the contrary, the vagueness lying at the heart of our language provides utility that enables us to operate effectively and efficiently in an uncertain world.

As systems safety engineers, we dislike vagueness because it reflects uncertainty. Nevertheless, as long as we continue using degree adjectives such as 'safe', 'reliable' and 'predictable' in our safety arguments, we will have to accept that linguistic vagueness is playing a central role. And rather than suffering unnecessary embarrassment, we should recognise the importance of this vagueness and work with it. Safety cases are written for an audience that was brought up on natural language and the one thing that linguists can say for sure is that natural language is riddled with vagueness. Yet, despite this, we are not frogs who boil in a bucket. We are perfectly capable of constructing a reasoned argument and acting upon it, enabled rather than challenged by the subtleties and mysteries of linguistic vagueness.

Crisply defined boundaries and quantified limits are all very well, but they can be false props that bring with them their own problems. So I invite you to consider the possibility that a safety case that is self-knowingly

vague in all the necessary places can be a lot better than one that deceives and bemuses the reader with unjustified precision and certitude. If you really don't know how big 'big' is, you are doing no one any favours by pretending that you do.

### Notes

1. As such, a vague expression is not to be confused with an ambiguous one. An ambiguous expression is one that has two or more interpretations, and for which a context is required to achieve disambiguation. Such ambiguity can be particularly problematic when it is still not obvious from the context which of the equally valid definitions is meant to apply. It is also important to understand that a loosely qualifying expression is not necessarily

vague. For example, 'less than ten', is not vague, since its applicability is straightforward. However, 'nearly ten' is vague, because the applicability of the term 'nearly' is not clear-cut.

2. This is actually an urban myth. Cruel scientists have determined that real frogs aren't that inattentive.

3. These include ideas such as Supervaluationism, Subvaluationism, Contextualism, Epistemicism, Fuzzy Plurivaluationism and Many-valued Logic. If long and horribly contrived words are your thing, see *Further Reading*.

### Further Reading

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*How Big is Big?* by an author unknown, and long out-of-print.

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## Conforming to IEC 61511: Operation and Maintenance Requirements

*by Steve Gandy*

It is hard to believe that the IEC 61511 standard has been in existence since 2003 and most companies operating in the process, chemical and refining industries (or any other process manufacturing) have adopted its practices. It is also significant that any plants with a Safety Instrumented System (SIS) will now be halfway through their useful life. It therefore seems opportune

to ask how well companies have been recording the performance of their SISs, in terms of failures, spurious trips, time to repair/restore and proof testing results. Furthermore, the new 2016 edition of IEC 61511 emphasises the need for assessment of SISs more strongly, so eaking in terms of preventing systematic issues through procedures and competency. This paper highlights how

testing and documenting the performance of the SIS is an essential part of ensuring that it is able to fulfill designated functional safety requirements. This is especially true as the SIS approaches the end of useful life.

### Introduction

Over the past decade or so, automation has been one of the dominant factors