Essay-2: Decremental and incremental approaches and objectives:

Presis: Decremental safety and incremental safety do not define two different types of safety, but two different ways or approaches to become safer and to achieve a state of safety. There can in fact be only one definition of safety, namely as the state where there are as few unexpected and unacceptable outcomes as possible. One of the problems of safety is how it is defined. Jim Reason nailed the definition problem, when he introduced the four paradoxes of safety (Reason, 2000). Understanding these paradoxes is important for any kind of safety-related activity, and is practically a precondition for incremental safety

The four paradoxes of Reason

The paradoxes of Reason do not refer to some fundamental issues in human reasoning, in the same way as the paradoxes of Russell and Zeno. In this case Reason is the surname of professor James Reason who described four safety paradoxes in an eponymous paper (Reason, 2000). The four paradoxes were:

1. That safety is defined and measured more by its absence than its presence.

   The first paradox is essentially about evidence. We have manifest evidence of the absence of safety, namely the UUOs, but we have no manifest evidence of the presence of safety, theEAOs and therefore no way to measure it. This is completely different in the case of quality. Here we know, based on statistical process control (Shewhart, 1931) that quality is present if outputs fall in the six sigma range above the Lower Control Limit (LCL) and below the Upper Control Limit (UCL), yet see (Hollnagel & Braithwaite, 2026). There is no similar formal foundation to define the presence of safety, unless we accept the ludicrous Zero Accident Vision (Zwetsloot, et al., 2013), Björnberg, et al. (2019), that itself is the subject of the fourth paradox Quality management, however, also includes a paradox, or at least an peculiarity, namely that more efforts are spent understanding the occurrence of outcomes outside the six σ range, than to understand the occurrence of outcomes that are inside the six σ range, even though these are the outcomes that are wanted. This is similar to the peculiar lack of interest in safety science and safety management to understand why work goes well, or the presence of safety, which actually is the rule rather than the exception.The first paradox is supported by the fact that whenever people experience an UUO they are likely to see it as illustrating the absence of safety, but it is practically never the case for an EAO that people spontaneously declare is illustrating the presence of safety. Whereas the OOUs are meticulously counted,yet no one counts the number of EAOs. In many cases the number is completely unknown, and not considered interesting.
2. That defences, barriers and safeguards not only protect a system, they can also cause its catastrophic breakdown. (This is practically a paraphrase of “the ironies of automation (Bainbridge,1983).

   The second paradox is essentially about the limitations of design, not least due to the problems with Work-as-Imagined (WAI). The efficacy of the defences, barriers and safeguards that are intended to safeguard the system depends on whether the designers have been able correctly to imagine the situations and conditions that may occur, how their safeguards will perform, and not least how people will respond.

The second paradox is therefore reminiscent of the classical problem known as the Ironies of Automation.The term Irony was used by Lisanne (Bainbridge, 1989), to describe a solution which could expand a problem it was intended to reduce or even eliminate. The term was first used in the context of automation, but can with equal justification be applied to other issues, such as safety and human factors itself. (Hollnagel and Dekker, 2024).

3. Many organisations seek to limit the variability of human action, primarily to minimise error, but it is this same variability – in the form of timely adjustments to unexpected events – that maintains safety in a dynamic and changing world. (This clearly predates the main idea of both resilience engineering (Hollnagel, Woods & Leveson, 2006) and safety differently (Dekker, 2015).

   The third paradox is essentially about the traditional view of the human factor (itself the topic of Esssay-3). When human factors was proposed by (Fitts, 1951), it was just called human engineering, with the purpose to enhance and improve the human factor, not only to ensure a better fit between humans and the machines they had to work with, but slso to make humans perform more reliably like the machines or technological artefacts they were compared to (Essay-4). The human operator waswidely seen as an unreliable, and possibly even error-prone system component, a view that the safety legacy quickly adopted (Essay-4). And the variability of human performance was seen as a liability, when we today realise it is an asset, as the third paradox also acknowledges. Human Error is a judgement in hindsight, as Ernst Mach argued already in 1905, but as this was part of a philosophical discussion rather than industrial safety, it went by largely unnoticed. Mach wrote that ”*Erkenntnis und Irrtum fließen aus denselben psychischen Quellen; nur der Erfolg vermag beide zu scheiden*” which in English means ”Knowledge and error flow from the same mental sources, only success can tell one from the other.” (Mach, 1905). In plain language ”people do what they do” and it is only afterwards we can determine whether it was a success or a failure. Today we would say that people always do what they believe is the way to act in any given situation as they see it. No one wants to do a bad job that leads to UUOs, everyone at both the sharp and the blunt ends wants to see EAOs as the result of their efforts. If they did not they would be fools. Sometimes, however, the way people understand a situation, comprising both risks and opportunities

may differ from reality. People do not see their work situation as it objectively is, cf. Essay Four, yet they rarely intentionally try to misunderstand it. (Politicians excepted, of course).

4. That an unquestioned belief in the attainability of absolute safety (such as the Zero Accident Vision (ZAV) can seriously impede the achievement of realisable safety goals, while a preoccupation with failure can lead to high reliability. This is a quiet warning against the Zero Accident Vision, advocating instead the need to understand why work sometimes does not go well.

The fourth paradox is essentially about the assumed usefulness of pursuing the Zero Accident Vision, (Zwetsloot et al.,2013) and (Björnberg, et al., 2019) the widely accepted ideal of the negative stance, and leads to a preoccupation with how UUOs occur, and a neglect of how EAOs occur, although the latter is far more useful than the former.

The first paradox is that “Safety is defined and measured more by its absence than its presence.” (Reason, 2000, p. 1.) This is amply illustrated by the common definitions of safety. The American Society Of Safety Engineers, for instance, defines safety as “the freedom from unacceptable risk.” (ASSE, 2011 p.13) The focus of practical efforts therefore is how best to reduce the number of unexpected and unacceptable outcomes to an acceptable level (ALARP), ideally zero, and the emphasis is on how to manage these, as demonstrated by the ubiquitous safety management Systems (SMS). Similarly, the International Civil Aviation organisation (ICAO, 2013) defines safety as ”the state in which the possibility of harm to persons or of property damage is reduced to, and maintained at or below, an acceptable level through a continuing process of hazard identification and safety risk management. (ICAO, 2013p. 1-2.).

In the same way the Agency for Healthcare Research and Quality (AHRQ) defines safety as “freedom from accidental injury,” which can be achieved by “avoiding injuries or harm to patients from care that is intended to help them.” Given this focus on the negative, it is little wonder that the concerns of decremental safety are expressed as risks. A risk denotes the likelihood or probability that something unwanted or unacceptable will take place or happen (Aven, 2006). The fact that safety in practice is defined more by its absence than its presence leads to problems in providing a simple definition of safety. It also raises the more serious philosophical problem of whether it is possible to prevent, or even manage, something that is absent?

the state of safety where there are as few unexpected and unacceptable outcomes as possible can be reached or achieved in two widely different ways. This is easily illustrated, by thinking of safety by a Safety Ratio (SR), as shown in Figure 1. the Ratio between the number of unexpected and unacceptable outcomes and the total number of outcomes.

Assume that the enumerator represents the number of expected and acceptable outcomes, arbitrarily called (S) While the denominator represents the number of unexpected and unacceptable outcomes, arbitrarily called (F). Then safety can be defined by the ratio SR of S to F. The analogy is simple, but hides a fundamental problem created by the safety legacy. We routinely count the number of unexpected and unacceptable outcomes, and are, in fact, often obliged to do so. These types of outcomes attract attention to themselves because they are unusual and often accompanied by distinct physical manifestations, such as loud noises, bright light (flames). On the other hand, expected and acceptable outcomes are rarely noticed or counted, unless they provide the basis for revenue.

$$SR = \frac{\text{(S) Expected and acceptable outcomes}}{\text{(F) Unexpected and unacceptable outcomes}}$$

Figure 1: The hypothetical safety ratio.

An example of this difference in real life is provided by the train collision that took place in Buizingen, Belgium on 15 February 2010 (RAIIU, 2012). Here two trains,each carrying 250–300 passengers, collided in snowy conditions during the morning rush hour. The trains fortunately came in contact laterally on parallel tracks at a set of points at the exit of the Halle station (Buizingen is a village in the municipality of Halle), rather than one train hitting the other head on. Still 18 people were killed and 162 injured, and there was major damage to the tracks. (Had it been a direct collision the number of dead and injured would have been far higher, and the material damage would also have been worse.) The investigation determined that one of the trains had passed a red signal without stopping an event called Signals Passed At Danger (SPAD), this happens so often, in Belgium and elsewhere, that it has acquired its own acronym.

This SPAD was seen as a contributing cause to the collision (the two trains should obviously not be at the same point on the parallel tracks at the same time. On further investigation, it was found that there were 130 SPAD events in Belgium in 2012, of which one third were serious (although there was no clarification of what serious meant). For unknown reasons it was also estimated that there were about 13.000.000 cases where trains stopped correctly at a red signal (this was a calculated number, since successful outcomes never are counted unlike

accidents and incidents, which are always carefully recorded) the probability of a SPAD was 10^{-5}. The probability of a serious SPAD was 3.3 10-6 and the probability of the accident itself was 7.7 10^{-8} which is four orders of magnitude lower than one in a million or 10^{-4}.

A less dramatic example is Frankfurt Airport which in 2011 had a total of 490,007 movements (these are counted), compared to 10 infringements of separation and 11 runway incursions, which likewise are counted.

In terms of the Safety Ratio, a larger value of SR, corresponds to better safety. In the best possible case F=1 (If F=0 as hoped for by the Zero Accident Vision, the fraction is no longer defined, because the denominator of a fraction cannot be zero.)

The Safety Ratio is useful because it clearly demonstrates there are two completely different ways to improve the ratio. The default way favoured by the safety legacy, decremental safety and Safety-I is to reduce the number of UUOs.The opposite way favoured by incremental safety and Safety-II is to increase the number of EAOs.

Elusive language.

The language or terms we use to describe safety are sometimes also problematic. We like to use the comparative term and say we aim to **improve** safety and make work **safer**. In light of the first Paradox of Reason, **safer** actually means **less unsafe**, hence to have a smaller number of UUOs rather than to have a larger number ofEAOs

One percent safer

The suggestion/recommendation to try to make work one percent safer is ethically impeccable.

As an illustration of language misuse, consider the one Percent Safer website [https://onepercentsafer.com/the-idea/] which includes the following text:

> "If we all do just one thing, just improve workplace safety by one percent, then that's 29,000 (actually 28,000, see below) people that get to go home without harm, instead of ending up dead – each year. 29,000 husbands, wives, partners, mothers, fathers, brothers, sisters, sons, daughters, friends, and co-workers. 29,000 humans.

(This rhetoric is problematic, although it is beyond dispute that every mother also is a daughter and every father is a son, and while someone can be both a father, a friend, and a co-worker, few people can be a brother and a sister or a son and a daughter at the same time, even if social norms are extremely relaxed.) The website [https://onepercentsafer.com/the-idea/] continues:

> "The fascination with chasing 'zero injury' targets is part of the problem, and we need to be more pragmatic. Instead of 'eliminating all harm', what if we could make the world 'just a little bit safer every day'? Pre-coronavirus, 7,616 people die every day. That's 2.78 million every year. If we could make the world 'a little safer', let's say - one percent safer - then nearly 28,000 people would continue to enjoy their lives with their loved ones, every year rather than 'dying on the job'.So, I was wondering: 'how do we save the lives of 28,000 people?" (In fact, only about 330,000 per year deaths result directly from sudden occupational accidents. One percent safer, would therefore amount to the lives of 33,000 people, considerably smaller than 28,000 but still an appreciable number.)

This is on the one hand and doubtless intentionally so, a strong emotional argument, for who would dare object to the possibility of saving lives. The argument is weakened, because safety is defined and measured more by its absence, by work-related deaths than its presence, One Percent Safer therefore only makes sense if the safety baseline – the current number of accidents or unexpected and unacceptable outcomes is larger than 100, otherwise one percent will be a fraction rather than an integer – and few businesses or endeavours can survive if their safety baseline is higher than 100,the International Air Transportation Association(IATA), could , for instance, report that there in 2022 there were 32.2 million flights and only 5 fatal accidents. A 1 percent improvement, as in one percent safer, therefore means 0.05 fatal accidents less, which is neither measurable nor meaningful in any sense. Similar examples from other domains are easy to find. So while One percent safer may be ethically impeccable, it may not make sense in practice. The statement "Instead of 'eliminating all harm', what if we could make the world 'just a little bit safer every day'?" proves that One Percent Safer remains committed to the ZAV, the approach is slightly changed, but the ultimate goal is still "to save the lives of 28,000 people", hence a decremental safety culture, to which the only viable alternative is an incremental safety culture.

The Allure of Vision Zero

The Zero Accident vision (ZAV) is an inescapable consequence of the first paradox of Reason. As long as safety is defined and measured more by its absence than its presence, the ultimate goal, the highest possible level of safety(sic!) (safest), is that there are no accidents, no UUOs at all. Humans have a strong motivation to avoid anything that can harm them, that is why we as societies wage wars on hunger and ignorance, it is also why all enlightened nations have extensive vaccination programs for children and adults in the case of pandemics. If we strive to be safer by reducing the absence of accidents (of UUOs) then the logical and inevitable result is a state with zero UUOs, even if the ZAV as not formally embraced as an ideal.This is so regardless of whether this goal is arrived at by many small steps, as proposed by one percent safer plea. The decremental approach is anyway in most cases the only practical solution. A quantum jump from the status quo to zero accidents is highly impractical, as well as excessively expensive, it is also likely to disrupt long-estasblished work routines, with unanticipated consequences. It has only happened once, on Sunday 3 September 1967, when Sweden changed from driving on the

left-hand side of the road to driving on the right. On the day itself, all non-essential traffic was banned from the roads from 01:00 to 06:00. Traffic accidents were therefore physically impossible. Essential traffic included ambulances, fire brigades, and police, but there were no known traffic accidents for these categories (The only possible accident would anyway have been that two vehicles from the above categories drove into each other on streets that were otherwise completely empty. The changeover saw a temporary reduction in the number of accidents, which predictably only lasted until people felt safe driving on the right hand side. Another example where a country changed from driving on the left side to the right is Austria that forcibly changed from driving on the left to the right happened on March 12, 1938, following the *Anschluss* (annexation) by Germany. Although some western regionsof Austia like Vorarlberg began switching in 1921, the entire country, including Vienna, was forced to change over to right-hand driving abruptly in 1938. Needless to say this change was not prepared as well as the change in Sweden 29 years later, and there are no known safety data from the change in Austria, but the *Anschluss* certainly caused a lot of damage throughout the country.

The ghost of Vision Zero is inseparable from the safety legacy and the decremental safety culture that follows from that, even if people deny it.The only certain way to exorcise the ZAV is to replace a decremental safety culture by an incremental safety culture.

Incremental and decremental safety cultures

Safety-I and safety-II, never did, and never intended to represent two different definitions of safety, although several people failed to understand that. (Leveson, 2020), (Aven, 2022), (Cooper, 2022), as well as Flinterman, 2024), and (Samost-Williams & Brook, 2025). Neither do Incremental and decremental safety represent different definitions of safety, but just two different ways of achieving a state of safety, in the same way that Safety-I and Safety-II did. The only sensible definition of safety is as “a state where there are as few UUOs as possible”. The word **safety** is in turn derived from the Latin word *salvus* which means, uninjured, unharmed and in good health (Raheemy, Sherratt & Hallowell, 2025), to be safe therefore means to be without or protected against the occurrence of UUOs (usually called harm and injury), whether actual (outcomes that happen now), or potential (outcomes that may possibly happen in the foreseeable future). Every sentient organism either tries to avoid situations where they can suffer injury or be harmed, they may try to make the threat disappear (which is why dogs bark at strangers, bears roar, and peacocks rattle their train), or to get away from such situations if the threat remains, typically by hiding, by seeking cover, by crawling or by fleeing (as all birds and winged insects do when we approach them). The "fight or flight" response (Cannon, 1915) is universal across species. Humans, as animals with cognitive abilities, especially the use of symbolic representation and memories of the past (history), as well as the ability to select some memories rather than all (corresponding to consciousness and also the ability to imagine what may happen in the future are naturally motivated to ensure a state of safety for whatever they do, both individually and collectively. This explains the importance both of feeling safe and of being safe (which, although often confused, are quite different, we sometimes feel safe even though we are not, and vice versa (Wilde, 1982)

Representing safety by the SR ratio, also defines two obvious ways to improve the ratio, one is to gradually make F smaller, corresponding to a decremental approach, the other is to gradually make S larger, corresponding to an incremental approach. For this analogy to work it is crucial that an outcome cannot be unexpected and unacceptable at the same time as it is expected and acceptable, at least not in the non-quantum world where we live and work. A more formal definition is that a decremental approach to safety works by reducing the number of unexpected and unacceptable outcomes to the possible minimum, always a real number, never zero, for the reason explained above.Conversely an incremental approach to safety tries to increase the number of EAOs to the theoretically possible maximum, always a real number, and in practice never 100 percent.

Another way of illustrating the two different approaches, the decremental and the incremental is using the analogy with a pair of scales (Figure 2).

The decremental approach relies on diminishing the number of UUOs, hence by removing something from the fight pan. The incremental approach relies on increasing the number of EAOs, hence by adding to the left pan.

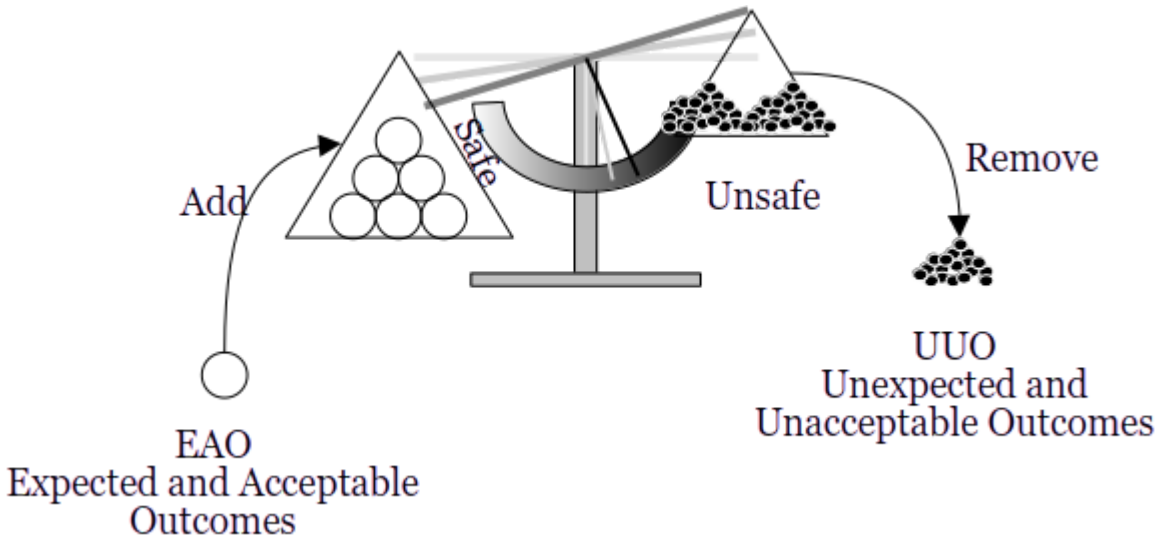

Figure 2: decremental and incremental approaches to achieve a state of safety

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