AVIATION SAFETY: THE ROLE OF HUMAN ERROR

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Abstract

Almost regardless of which source we use, which article or newspaper we read, our industry seems to have almost unanimously agreed that 70% of all accidents or incidents are down to 'Human Error', varying from 'pilot judgment and actions', 'situation awareness' to 'unsafe acts and errors.'[1] [[2]] Terms most of us are familiar with or have become accustomed to, even though precise definitions or meaningful explanation what we *actually* mean by such terms are often absent. Interestingly and at the same time, the term 'human error' and especially, its use in today's management of safety, is increasingly being criticised. Criticism includes that the term would not sufficiently explain what has happened in cases of accidents or incidents and it would hamper investigators from looking sufficiently at context or other possibilities. In turn, this would mean that we are overlooking important lessons learned and safety could actually be compromised rather than managed in today's complex world.

Introduction

Safety and safety management are at the core of many industries and societies these days. Our governments, organisations and very much the public have become less tolerant of adverse outcomes and safety and accountability are at the core of day-to-day management of organisations, politics, possibly even daily life.

The current and historic helicopter accident rate is often said to be too high. An initiative to reduce accident rates worldwide by 80% by 2016 was launched in 2005.[3] Effort has gone into the improvement of safety and new regulations, technology and training initiatives have been implemented to reach this target.

Much of our studies, investigations and implementation of safety measures, procedures and technologies, are informed by the overwhelming and very convincing finding that 70% of all helicopter accidents are caused by 'human error'.[4] [5] A number that is similar to other industries and is frightening and logically leads to our efforts being concentrated on human performance and reliability in an attempt to reduce the catastrophic effects our performance can have.

At the same time, originating from other industries, the term 'human error' as a cause for adverse outcomes is increasingly criticised. In short, the linear approach we have adopted in safety thinking of which 'human error' is an essential part, does not suffice anymore in today's world of increased complexity. Whether the term 'human error' as a cause for incidents and accidents should eventually disappear from our safety language or whether it should be regarded as a symptom for systemic failure is part of today's debate on new approaches to safety and safety management.

What is 'Human Error'?

Human error means that something has been done that was "*not intended by the actor; not desired by a set of rules or an external observer; or that led the task or system outside its acceptable limits.*"[6] Human error can simpler be described as a deviation from intention, expectation or desirability[7]. Essential in this discussion about error are 'intent' and 'outcome' linked to certain behaviour or performance.

A widely used and accepted distinction between 'active' and 'latent' errors is related to the outcome or the effect. In classic human factors latent errors are defined as actions with a delayed effect and active errors as errors with an immediate effect. Examples of latent errors could be understaffing,[8]

procedure implementation, oversight and regulation, maintenance procedures and more.[9]

Three types of error are distinguished: slips, lapses and mistakes. Slips and lapses are caused by inattention and could be described as a 'good plan, but a lousy execution'. Examples of slips could be pressing a wrong switch, 'a slip of the tongue', etc. Simply put, slips are mostly described as skill related errors, where the action was not intended as it happened.

Lapses are more 'failures to act' than actions, as they are related to forgetting things: the original at a printer, leaving the key inside the house when the door has just fallen shut behind you, missing an item on the check list and so on. Also lapses are said to be caused by inattention.

Mistakes are often referred to as 'the wrong plan' that are correctly executed: human beings do not always understand their situation due to lack of information or time. Our view at a moment in time provides information on which we base our next action (plan). When our information is wrong, our interpretation is wrong, our plan is wrong, hence we do the wrong thing: a mistake.

Error and Violation

 'Intent' separates error from violation. A violation is when people knowingly or willingly bend rules[10] (also referred to as non-compliance). Hudson et al (2008) describe after a small discussion on different views in the literature, three types of violation:

- Situational (when the situation makes it impossible to carry a task out correctly);
- Optimising
    - for own benefit (the individual gets a benefit)
    - for company benefit (pleasing managers, supervisors, colleagues, etc.)

- Exceptional (one-off situations that may not have pre-set rules or guidance).

Later on, two categories 'unintentional violation' and 'routine violations' were added (Hudson, 2012). An unintentional violation has occurred when people did not know, or did not have access to the rule. We speak of routine violations when any of the above mentioned violations, have become the norm.

Just Culture

The main difference between error and violation is 'intent', when people knowingly violate the existing rules.[11] This difference is important, as it justifies many disciplinary policies across aviation and other industries. The management of 'error' and 'violation' is often related to the term Just Culture: an 'atmosphere of trust in which people are encouraged, even rewarded, for providing essential safety-related information - but in which they are also clear about where the line must be drawn between acceptable and unacceptable behaviour.[12]

The theory above and related 'culpability models' are based on the assumption that human error is accepted and even a natural part of every social system. Violation, on the contrary, is not necessarily and needs to be managed: '…the concept of Just Culture… providing managers with a clear procedure for deciding whether a violation is to be treated as blame free or whether some form of coaching or discipline is appropriate…. The logic is that individuals who break the rules should not be punished if it becomes clear in an investigation that there is no attempt at sabotage or deliberate creation of danger…. If, however, it was apparent that the procedure was clear and workable then the individual should be subject to punishment, up to and including dismissal'.[13]

What all models have in common is that they start with the questions 'Was the outcome as intended?' and 'Was the act as intended?'. When both can be answered with a 'no', it is

a genuine error and people involved are 'blame free'.

In any other case, we do not talk about error anymore and such models guide us past a line of increasing culpability and the related behavioural corrections that could be imposed onto the individual who committed the error or violation. Training, change in procedure or guidelines are part of mitigation strategies here. Dismissal is justified when the action as well as the outcome was intended, as in such cases we talk about sabotage.

Safety thinking over the years

What is described above are very well accepted terms and practices in aviation today. They fit in well with many present views of safety management applied in our industry today. However, these views have not always been the same.

In the early days of aviation, safety was not understood the same way as it is today. The early days were characterised by trial and error, many accidents happened and causes for failure were attributed to underdeveloped technology and inferior materials. This time is described as the Technological era. [14] [15]

Later on, with advances in technology and increased regulation, causes of failure were no longer ascribed to technological failure, but mainly to non-compliance and error. For decades, with the help of technology, regulation and training we have tried (successfully) to reduce human error and their adverse effects. This so-called 'Human Factor era' has dominated our view on safety for the last decades and still continues to do so today.

The understanding that human beings do not work in a vacuum and that they operate in a far more complex environment today than ever before has led to a shift in safety thinking more recently: our focus should shift towards the organisation rather than the individual. This shift is exactly the change that is behind legislation and initiatives towards

formalised Safety Management Systems. Already, while many organisations, regulators and people having to get used to this new approach to safety, developments towards the 'systemic era' are already on their way, including today's complexity of operations and looking at safety from a resilience engineering point of view.[16]

The 'shift' from the Human Factors era to the so-called Organisation era and possibly even beyond, is not possible without having a close look at 'human error'. This is because the assumptions on which we have based our safety view for decades, are simply not compatible with practice anymore. Especially the assumptions underlying the Human Factors era are in full conflict with what safety management today wants to achieve and focus on: performance based safety rather than mere compliance.

However, the proposal is not to replace one view with the other, but to question our assumptions and ask if they are still meaningful in today's world and especially in our highly complex industry. The 'label' of 'human error' as a cause for accidents and incidents' may well be based on assumptions that are not realistic anymore today. To hold on to this view of people and their work may have adverse effects on people, organisations and safety as a whole.

Human error in a safety context

Our traditional safety view on human performance basically look at performance in two ways, good and bad performance, where 'human error' and 'violation' belong to the latter[17]. Based on the belief that work as imagined = work as done it has been a common assumption that as long as people comply with rules and minimise errors, systems would be much safer. [18] [19] Lack of performance reliability of humans is viewed as a threat, as people do not work as machines and they sometimes get it wrong. With procedures, rules, training and technology we control human behaviour as much as we can. Furthermore, we focus on

things that go wrong: incidents and accident and safety is viewed as an absence of harm.[20]

Our traditional safety view is characterised by the following assumptions:

- *Complex systems would be fine, were it not for the erratic behaviour of some unreliable people in it;*
- *'Human errors' cause incidents: more than two-thirds of them;*
- *Failures come as unpleasant surprises and do not belong in the system. Failures are introduced to the system through the inherent unreliability of people.*
  The old view maintains that safety problems are the result of a few people in an otherwise safe system. [They] do not always follow the rules, they do not watch out carefully. They undermine the organised and engineered system that other people have put in place'. [21]

Rules, procedures and management measures (disciplinary action) are used to combat the non-compliance and control behaviour. Important to note is that the focus is individual; bad attitudes and behaviours are the cause of trouble and error and non-compliance have become a personal and motivational problem.[22] A conclusion often heard is that if people would adher to rules and pay more attention, our otherwise perfectly safe systems would indeed be safe. All this, over time has led to a deep-rooted assumption in our in our society that: '*If something goes wrong, someone must have done something wrong!'* [23]

Alternatively, Reason puts forward that *'rather than being the main instigators of an accident, operators tend to be the inheritors of systems defects created by poor design, incorrect installation, faulty maintenance and bad management decisions. Their part is usually that of adding the final garnish to a lethal brew whose ingredients have already been cooking.*[24] Such observation puts the organisation and context back into

consideration and some focus away from the individual as the root-cause of failure.

One of the main drivers behind a transition in our view on 'human error' is increased complexity. [25] The 'new view', which is introduced here, acknowledges the complexity of the systems in which people work: *'people who work in these systems learn about the pressures and the contradictions, the vulnerabilities and pathways to failure. They develop strategies to not have failures happen. But these strategies may not be completely adapted. They may be thwarted by the complexity and dynamics in which they find themselves. Or vexed by their rules, or nudges feedback they get from their management about what "really" is important (often production efficiency). In this way, safety is made and broken all the time.*[26]

In other words, 'human error' is not about the simple observations of individual error, lack of awareness or lack of attention, *'it is about an organisational story, about the complexity in which people work, about technology, governance, operation and administration:*

- *Safety is never the only goal, they exist to provide goods and services;*
- *People do their best to reconcile different goals simultaneously;*
- *A system is not automatically safe: people actually have to create safety through practice at all levels of the organisation;*
- *The tools or the technology that people work with create opportunities and pathways to failure.*[27]

An example of how people in an organisation need to deal with complexity and different goals simultaneously from helicopter maintenance:

'Helicopter maintenance is conducted in different ways in the respective countries. It was regarded as unfortunate to standardise maintenance across national borders. Norway's maintenance work is divided into areas as cabin, rotor,

fuselage, tail section. In other countries, work descriptions are used which cover more areas. This results in there being more people working on the entire aircraft. From a Norwegian perspective "going to and from" in this way makes it difficult to get the whole picture, and it asserted that this approach leaves more room for mistakes.

It has been pointed out that a shortage of spare parts can constitute a safety risk. Generally, today it takes a "very long time" to get spare parts. The lack of resources and spare parts can be seen as an increase in the trend of applications for "Maintenance Deviation Requests". This, along with changes in management, creates frustration among the maintenance personnel. There is much pressure on regularity, but if a machine has critical faults, the helicopter will of course be grounded. To be able to keep the helicopters in the sky, an increase in "cannibalism" is experienced […] "Cannibalism" is fully legal as long as the specified procedures are followed, but this results in two operations being performed instead of one. With this, there is increased pressure on the maintenance organisation, especially if helicopters must wait, and it can lead to penalties from the customer.

[…] Quote: "An email came from the management saying that if we could maintain over 90 per cent regularity for one week, they would buy cake for all the bases. But then the employees answered in email saying that if the management could provide parts for the entire week, they would buy cake for the entire management." [28]

Changes in View: Practical Drift

One of the most important differences in today's view on safety is the acknowledgement of 'Practical Drift' This phenomena, originally from Scott A.Snook[29] is adopted by ICAO and serves as a foundation of safety management as we know it today. 'Practical Drift' describes the performance of every complex system, including socio-technical systems like organisations and operations.

Source: Scott A. Snook
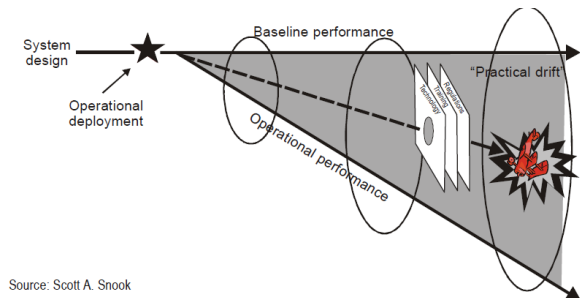
Complex socio-technical systems are designed to operate in a particular way (system design). Once a system is 'deployed' into the real world, it behaves differently over time than it was originally designed to, called operational performance. Over time, a gap develops between baseline performance (as designed) and operational performance (how the system actually operates): Practical Drift. The bigger the gap, the more chances there are for adverse outcomes.

For years, in classic safety management, we have tried to minimise this gap: by putting regulation, training and technology in place, we try to keep operational performance as close to baseline performance as possible. This is perfectly in line with our understanding of safety management in the 'Human Factors' era: we try to control the system and its people by rules and procedures, training and technology. Compliance is the main denominator for safety.

What is different today, is that it is actually acknowledged and accepted that practical drift is inevitable: people and systems adjust to their context in order to meet their operational ànd safety goals[30]. ICAO (2009) summarises the three main changes in our safety view today:

Human era	Organisation era
• Baseline performance • Compliance based • Outcome oriented	• Performance is not baseline • Performance based • Process oriented

The above basically implies that we have to concentrate on operational performance rather than baseline performance. As both Dekker (2014) and Hollnagel (2014) describe it: we need to focus on 'work as done' instead of 'work as imagined.' In itself, this change seem logical and quite straight forward. However, the shift from compliance- to performance- based safety and the realisation that performance is not baseline, has huge implications for how we view safety management, especially how we view human performance or 'human error'.

So, what is so problematic ' Human Error' as a cause for incidents and accidents

At the moment most of us view safety as the absence of harm [31] and our view of safety management is characterised by the law of causality and rationality[32]. *Causality (also referred to as causation) is the relation between an event (the cause) and a second event (the effect), where the first event is understood to be responsible for the second. In common usage, causality is also the relation between a set of factors (causes) and a phenomenon (the effect). Anything that affects an effect is a factor of that effect. A direct factor is a factor that affects an effect directly, that is, without any intervening factors.* [33]

The rationality assumption is that it is possible to 'reason backwards in time from the effect to the cause.' [34]Both causality and rationality assumptions are logic and convincing, hence, together these two views shape our safety vision as it is today. Our incident and accident investigations are always aimed at finding (the) root cause(s) so that we can learn from an event, possibly

eliminate these root-causes in order to prevent such incident/ accident from happening again.

Hence, it is perfectly accepted that we investigate adverse outcomes, serious incidents and accidents. However, both error and violations are *defined* in their relation to *outcome*, an undesired effect, an unstable system, an incident or accident. In other words, error and violations are labels that are most assigned *in hindsight of a bad outcome.* [35]

Even though some investigations include elements of the context and so called 'human factors', a conclusion is too often 'human error' as the root-cause: if person Y had not done X, the bad outcome would not have occurred. However, what is not investigated, is how often the same 'error' or 'violation' has *not* led to an adverse outcome.

In other words, the majority of our operations do *not* end in an incident or accident, but it would be extremely unlikely (if not naïve) to assume that 'error' and 'violation' do not occur. An incident or accident is singled out and investigated in depth (rather than width) [36], but without knowing if, and how often, the same or very similar situations have *not* resulted in an unwanted event. [37] So, our safety focus includes a very small percentage of our operation and leaves out a wealth of useful information: understanding of why things go right! [38]

Another but related problem with the focus on outcome and backtracking to 'the root-cause' is hind-sight bias: with the knowledge of the outcome it is relatively simple to interpret situations and actions. [39] However, people who were in that situation at that time, did not have this knowledge. The 'local rationality principle' explains that what people do makes sense to them at that time in that situation. [40] Put bluntly, mechanics do not come to work to damage aircraft or equipment, pilots do not check in to get hurt, nor hurt any of their passengers, or anyone else…

In the extreme rare cases this would have been the case, we could not talk about an accident anymore, but about acts of sabotage or terrorists, which has nothing to do with human error[41].

The belief that we can 'backtrack' events to causes, actions and decisions and draw conclusions about the motivation, intent or behaviour of people, lead to an assumption that people always had an option to *not* commit a specific error. In other words, that people always have a choice A (do) or not do (B). Unfortunately, *in hind-sight* this is a possible, but too simple conclusion to draw. This is an oversimplification of reality, where we most often have a scale of options to choose from, which we (mostly successfully) do. In other words, choices and actions can realistically not be simplified to A and B[42].

Classifying human performance as 'good' or 'bad' in terms of error and violation in hindsight of a bad outcome, is a complete disregard of context and reality. Context and operational goals are much more complex than a simple interpretation of 'compliance or not', *even if rules and procedures would be clear and workable.* In reality, most people in organisations are managed on results or 'KPI's' (Key Performance Indicators) most often based on operational goals (less down time, increased turnover, customer satisfaction, etc. etc.), which are most often conflicting with 'safety goals'. In reality, this means that people are juggling between many goals at one given time. And, choosing to prioritise an operational goal is fine (often preferred) *as long as safety is not jeopardised!*

'…our response to error and mistakes that end badly is to spew out more policies, disciplinary measures, warnings, naming and blaming. Mistakes that don't cause repercussions somehow tend to escape moral and ethical labels'. [43] In other words, error and violations can be seen as 'ok', as long as there is no negative outcome, but are seen as a moral wrong-doing when brought in relation to a negative outcome. [44]

Unfortunately, in many cases, one of the first things investigated if there has been an incident, is if rules have been complied with (a comparison between work-as-imagined and work-as-done) and often such 'violation' is easy to find. Even more unfortunately, this is normally where an investigation stops. However, when really focusing on 'work as done' an observation will be made that like 'error', 'violations' are just as natural to socio-technical system. In many cases, they are only classified as 'unacceptable behaviour' if they come to light in the investigation of an incident.

The term 'violation' becomes questionable in performance based safety. We need to focus on work as done and this is impossible if we use too strong judgment on most of the time perfectly rational behaviour. Practical Drift can be described as a 'slow but sure departure from ideas how to operate a system[45] and is caused by rules that do not match the work, room to manoeuvre to do work quicker, better, smarter…, local efficiency and because past successes are seen as a guarantee for the future[46]. In other words, practical drift is caused by the complexity and demands of daily operations and can therefore not be simply labelled as 'error' and/or 'violation'. Finally, departures from a routine become the routine. [47]

Importantly, it is to note that it is not stated here that non-compliance would be a good thing. Compliance, regulations, technology, training and more have made aviation, including the rotorcraft industry as safe as they are today. However, with increased complexity and the need to actually understand the operational performance of our industry and its organisations, the *hindsight labels of human error and violation as a root cause for failure* that is being used to control people's performance, has lost its usefulness.

Lastly, it is safe to assume that people come to work to do a good job[48]. We trust them with expensive equipment and the life of passengers and they succeed most of the

time. It cannot be that on the basis of a (*one*) bad outcome, the intentions and capabilities of otherwise professional and capable people, all of a sudden are being questioned.

Human Performance

Hollnagel proposes another way of looking at human performance: "…*it is a fundamental characteristic of human performance, whether individual or collective, that the resources needed to do something often, if not always, are too few. The most frequent shortcoming is a lack of time, but other resources such as information, materials, tools, energy, and manpower may also be in short supply. We nevertheless usually manage to meet the requirements to acceptable performance by adjusting how we do things to meet the demands and the current conditions - or in other words to balance demands and resources. This ability to adjust performance to match the conditions can be described as a trade-off between efficiency and thoroughness.*"[49]

The maintenance example above describes this 'ETTO-principle' clearly: the workers have to perform within the context of a lack of spare parts, time pressure and higher workload, where at the same time they are requested to keep the regularity as high as possible. This situation leads to a continuous balancing of priorities and performance adjustment (performance variability) and usually people get this *right*. In other words, performance variability is *required* in order to make our systems work! If people would *not* be able to adjust to their environments, systems would not be able to perform as well as they do. In other words, people create the output as well as the safety, through managing between efficiency and thoroughness daily.[50] [51]

Looking at 'human error' from the 'ETTO-principle' it is more than likely people have made a similar trade-off before (possibly many times) *without* an adverse outcome. If this is the case, the so-called 'error' cannot be 'the root-cause', as it cannot be justified

that *only* in the case of a bad outcome we judge behaviour as 'not thorough enough' as in all other cases, the same behaviour is fine.

In other words, it is the *same* human performance that makes the system safe and sometimes not. Therefore, the label of human error as a cause for failure, is not meaningful.[52] [53] It takes us away from looking at alternatives, to understand better what (may) cause our systems to fail. In other words, such label stands in the way of learning, understanding our systems' complexity and therefore, safety.

Learning and Accountability

In the introduction it is stated that learning and accountability are at the heart of safety management the way we know it today. Organisations must have a reporting system where people can report any hazards, near-misses, incidents from which the organisation can learn, where needed intervene in order to prevent bad outcomes from happening (again). Learning is at the heart of managing safety.

Accountability is *answerability, blameworthiness, liability, and the expectation of account-giving […] accountability is the acknowledgment and assumption of responsibility for actions, products, decisions, and policies including the administration, governance, and implementation within the scope of the role or employment position and encompassing the obligation to report, explain and be answerable for resulting consequences.*[54]

'Just Culture' according to Dekker (2008) is about balancing learning and accountability[55] as these two concepts are compatible and the essence of how we view safety today.

However, when 'Just Culture' is used in the way it has previously been introduced, the balance of learning and accountability can never be reached. In other words, when 'Just' means being judged and disciplined on the basis (of the gravity) of unwanted

outcome, we have come further away from learning and accountability than we were before.

A different way of viewing safety has not taken away the responsibility of organisations to manage, support and train their people. However, people management, with all their different skills, styles, talents and characters, is an ongoing process *regardless* of failures in the system.

The 'need' to be able to punish people when they have done something wrong, is a false sense of control when this is done based on adverse outcomes, as is suggested in 'Just Culture' and culpability models as proposed by several organisation and writers.

In contrast, such 'justification' will reach the effect that people need to hide error or certain actions or crucial information as 'fear of blame' has become a real mechanism of control. Unfortunately, with the result that information does not surface anymore, learning is hampered and the understanding of operational performance has become a myth. Basically, it means that such organisations are back to the assumption of work as imagined= work as done, but now with a 'Just Culture' tool to justify pushing blame to the sharp end.

On the contrary, we trust our people with expensive equipment, tools, colleagues and passengers. We trust our people to carry out important, necessary and sometimes dangerous missions in helicopters that save people's lives, generate income and profits, that benefit the industry and the public.

Making people and organisations accountable, means involving them in decision making, rule- and procedure making and letting them tell about their stories and experiences of which the organisation and the industry can learn.

A balance between accountability and learning can only be struck if the room and opportunity is created to look at and understand 'work as done' and let go of some

myths around safety and especially 'our dependency on human error as a near universal cause of incidents. [56]

Conclusion

All people err, make mistakes or get it wrong in the efficiency-thoroughness trade off. We fall of our bikes, trip over curbs, and so on. These examples can be seen in very simple cases or actions where cause and effect are indeed directly related.

However, in our highly complex, regulated, controlled industry, it is very rare that *one* such error *alone* would cause a disaster, especially if the same behaviour does not end in failure in similar or the same situation. If this would be the case, it means that others (can) make the same error with the same catastrophic effect. This would however, indicate a flaw in the system rather than an individual flaw in competence or motivation.

What is criticised in this article is the nearly '*a priori* conclusion that if something goes wrong, 'human error' *must have been the root-cause.* Preferably, an error at the front-line. Discipline or remove the person and the system is safe again. This *a priori* conclusion is justified by myths, that simply do not hold in today's complexity anymore.

Observation, conversation and experience show that this 'human error' as a label causes problems in real life for our pilots, mechanics and many other professionals. They have to fly and work under increased economic and legal pressure in an atmosphere of knowing that 'getting it wrong' may have severe consequences.

Instead, *'…human factors and safety research has pretty much always been on the side of the human operator. It has tried to explain performance problems not by reference to behavioural or motivational shortcomings but to systematic relationships to the design of the equipment we make people work with (Fitts and Jones, 1974) The purpose […] is to make the world a better place for human operators, to increase their*

effectiveness, to support their performance…[57] And this is exactly what standardisation and human factors have done for safety so far and hopefully, continues to do successfully.

Convincingly in their work, Hollnagel, Dekker and many others show us what the drawbacks are for safety and the well-being of our people and therefore the industry if we would stick to our 'labels' that keep things simple, but certainly *not* safe.

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