HindSight 25

The ability or opportunity to understand and judge an event or experience after it has occurred

EUROCONTROL

WORK-AS-IMAGINED & WORK-AS-DONE

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The "put-yourself-in-other's-shoes" concept for safety culture

Frank Brenner has worked in Air Traffic Management for his entire career. He has been Director General of EUROCONTROL since 1 January 2013.

Since taking up his functions at EUROCONTROL, he has initiated the development of a Vision and Strategy, including the development of Centralised Services as part of the SESAR deployment concentrating on how to support controllers with new technology which increases safety.

Before joining EUROCONTROL, Frank Brenner was General Manager Operations for FABEC, Vice Chairman of EUROCONTROL's Performance Review Commission and a member of the Performance Review Body. Trained as an air traffic controller, he has held a number of posts at DFS including Head of ATM Operations, Director of Operations at the Business Unit for Aeronautical Data Management and Director of DFS's Control Centre Business Unit. operational posts.

Dear readers,

For anyone who has had to assemble flat pack furniture, the potential gap between work-as-imagined (the version in the showroom) and work-as-done (the result at home) is clear. It is almost a cliché that something will go wrong – particularly as the instructions are either just diagrams or are written in a way that only vaguely approximates to your own language.

This is not only a problem for the purchaser, it's also a problem for the company making and selling the furniture. So there is a real incentive for the designer/manufacturer to reduce customer frustration, customer service calls and the returns of incorrectly assembled bits.

The first step is to recognise the problem and the same is true in aviation. There are some excellent examples in this edition's articles of how work-as-done is not as-imagined, even by ourselves. Often, this is for the best of reasons, to help out someone else, to save some time or some fuel, or because it is easier than following the official procedure.

The responsibility also lies with those designing the systems and writing the procedures. The blind assumption that everyone will follow the rules exactly, all of the time, is not realistic and, as a result, it is not safe. So it is necessary to ask the questions "What will or could happen in practice? What problems may arise that cause people to take a short cut, or make the official procedure unworkable?" One of this edition's articles, by Captain Starke, looks at this topic with the challenging title "Imagine Reality".

This is particularly important currently, with so much change happening – ranging from the introduction of free routes airspace to new arrivals management techniques to increases in runway throughput. A lot of work goes into simulating and validating changes to try to anticipate problems. Sometimes, these are identified during the training phase.

However, the task is not complete once the new system or procedure is in place. It is at this point that the real comparison between 'work-as-imagined' and 'work-as-done' becomes possible – and necessary. Feedback is essential so that systems and procedures can be refined to reflect the test of reality.

The good news is that it is possible to narrow the gap between 'work-as-imagined' and 'work-as-done'. We can see this in my example of flat pack furniture where the best manufacturers now put in a lot of effort to minimise the number of mistakes you can make. So the side of the cupboard is now symmetrical top to bottom – there is no 'wrong way round'; the instructions are much clearer and also highlight areas where a mistake could conceivably be made. As a result, the chance of ending up with too many (or too few) pieces has been greatly reduced.

For us in aviation, the consequences can be much more serious than a collapsing wardrobe. This edition shows some fascinating examples of how the gap between 'work-as-imagined' and 'work-as-done' still exists and also how it can be addressed. Everyone can help, all the way from system design to the highlighting of issues in everyday operations.

Frank Brenner
Director General, EUROCONTROL

GREETINGS!

Welcome to this 25th edition of HindSight magazine. I have read this publication for many years. Under the Editorship of Tzvetomir Blajev, HindSight has grown into a world-class magazine, distributed to over 6000 people in paper form, and many thousands more electronically. I see three ingredients that make HindSight unique. The first is a focus on the operational safety of air traffic services. The second is a main readership of controllers and pilots. The third is a mix of articles from both front-line operators and those who seek to support the vital work of front-line operators. I am in the latter category. In the summer of 1997 I joined NATS as a human factors specialist, working on incident analysis, safety assessment, technology design, and real-time simulation. In the 20 years since, I have had the pleasure to meet many hundreds of you who may well be reading this issue, in ops rooms, simulators, meetings and workshops. You have taught me almost all of what I know about this industry and your work. I hope that HindSight continues to help you to create safety in your daily work. I always enjoy hearing from you, so please get in touch with any thoughts that you have about your magazine: HindSight.

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INVITATION, PARTICIPATION, CONNECTION

Steven Shorrock
Editor in Chief of Hindsight

We need to come together to improve work-as-imagined and work-as-done.

If a friend asked you what makes your organisation and industry so safe, what would you say? Our industry is often considered 'ultra-safe', and yet we rarely ask ourselves what keeps it safe. What are the ingredients of safe operations?

When we ask this question to operational controllers as part of the EUROCONTROL safety culture programme, it is revealing to hear how far outside of the ops room the answers extend. Operational work is of course done by operational people, but it is supported by a diverse range of people outside of the ops room: engineers and technicians, AIS and meteo staff, safety and quality specialists, technology and airspace designers, HR and legal specialists, procedure writers and training specialists, auditors and inspectors, senior and middle managers, regulators and policy makers.

Each of the above has an imagination about operational work – as they think it is, as they think it should be, and as they think it could be. (Operational also have some imagination about non-operational work!) We call this *work-as-imagined*. It is not the same as the reality of work activity: *work-as-done*. The degree of overlap depends on the effectiveness of interaction between operational and non-operational worlds.

This is important because non-operational imaginations produce regulations, policies, procedures, technology, training courses, airspace, airports, buildings, and so on. These need to be 'designed for work-as-done'.

Designing for work-as-done requires that we bring together those who do the work and those who design and make decisions about the work. We have talked with over a thousand people, in hundreds of workshops, in over 30 ANSPs, to discuss work and safety. While there are some excellent examples of interaction and cooperation (e.g., new systems, procedures and airspace), there are also many examples of disconnects between work-as-imagined and work-as-done. Where this is the case, people have said to us that operational and non-operational staff rarely get together to talk about operational work.

With this issue of HindSight, we wish to encourage more conversations. But how? In their book *Abundant Community*, John McKnight and Peter Block suggest three ingredients of a recipe that can be used to bring people together.

1. Invitation

Think of the boundaries of your work community and your workplace. Is there a 'welcome' mat at the door, or a 'keep out' sign? Several barriers keep us apart:

- *Organisational barriers:* Goals, structures, systems and processes that define and separate functions, departments and organisations.
- *Social barriers:* 'In-groups' (us) and 'out-groups' (them), defined by shared values, attitudes, beliefs, interests and ways of doing things.
- *Personal barriers:* Individual choices and circumstances.
- *Physical barriers:* The design of buildings and environments.

We must look honestly at these barriers because by separating us they widen the gap between work-as-imagined and work-as-done. According to McKnight and Block,
"The challenge is to keep expanding the limits of our hospitality. Our willingness to welcome strangers. This welcome is the sign of a community confident in itself."
Hospitality is the bedrock of collaboration.

How can we reduce the separating effects of organisational, social, personal and physical barriers, and extend an invitation to others, inside and outside our 'community'?
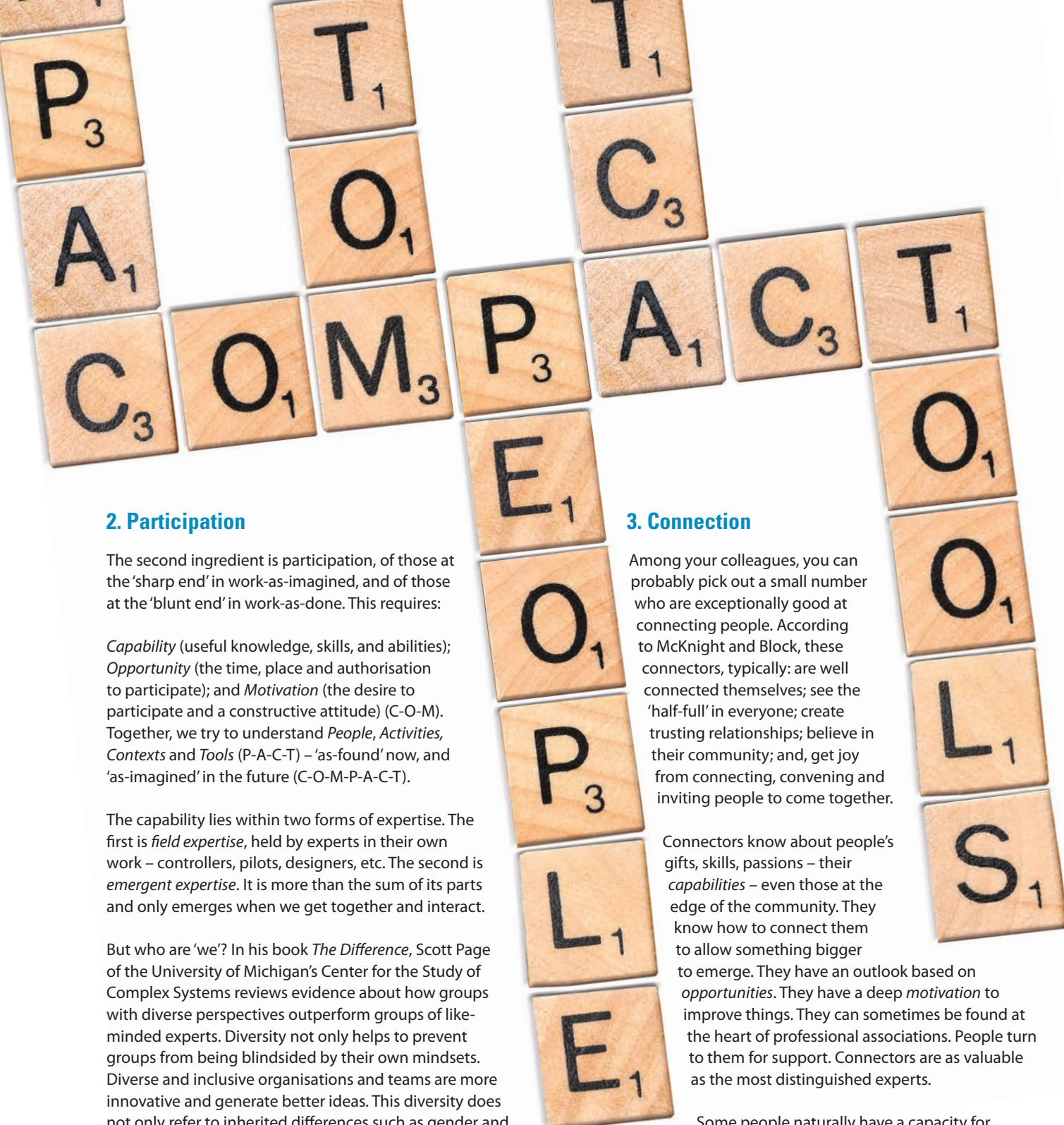
2. Participation

The second ingredient is participation, of those at the 'sharp end' in work-as-imagined, and of those at the 'blunt end' in work-as-done. This requires:

Capability (useful knowledge, skills, and abilities); *Opportunity* (the time, place and authorisation to participate); and *Motivation* (the desire to participate and a constructive attitude) (C-O-M). Together, we try to understand *People, Activities, Contexts* and *Tools* (P-A-C-T) – 'as-found' now, and 'as-imagined' in the future (C-O-M-P-A-C-T).

The capability lies within two forms of expertise. The first is *field expertise*, held by experts in their own work – controllers, pilots, designers, etc. The second is *emergent expertise*. It is more than the sum of its parts and only emerges when we get together and interact.

But who are 'we'? In his book *The Difference*, Scott Page of the University of Michigan's Center for the Study of Complex Systems reviews evidence about how groups with diverse perspectives outperform groups of like-minded experts. Diversity not only helps to prevent groups from being blindsided by their own mindsets. Diverse and inclusive organisations and teams are more innovative and generate better ideas. This diversity does not only refer to inherited differences such as gender and nationality, but also diversity of thought, experience and approach. Multiple perspectives, including outside perspectives, are a source of resilience. If you are a controller, imagine a supervisor from another ANSP's tower or centre observing your unit's work for a day or so, and discussing this with you, perhaps questioning some practices. They would likely see things that you cannot.

How can we increase diverse participation in the development of policies, procedures, and technology, and in the understanding of work-as-done?

3. Connection

Among your colleagues, you can probably pick out a small number who are exceptionally good at connecting people. According to McKnight and Block, these connectors, typically: are well connected themselves; see the 'half-full' in everyone; create trusting relationships; believe in their community; and, get joy from connecting, convening and inviting people to come together.

Connectors know about people's gifts, skills, passions – their *capabilities* – even those at the edge of the community. They know how to connect them to allow something bigger to emerge. They have an outlook based on *opportunities*. They have a deep *motivation* to improve things. They can sometimes be found at the heart of professional associations. People turn to them for support. Connectors are as valuable as the most distinguished experts.

Some people naturally have a capacity for making connections, but each of us can discover our own connecting possibility to help improve work-as-imagined and work-as-done.

Who are the connectors in your community, and how can they and you help to improve and connect work-as-imagined with work-as-done?

In this issue, you will read about work-as-imagined and work-as-done from many perspectives. In reading the articles, we invite you to reflect on how we might work together to bridge the gaps that we find.

Enjoy reading HindSight! ⅁

MALICIOUS COMPLIANCE

by Sidney Dekker

As a schoolboy in the 1980's, my parents took me and my brother and sister to East Berlin. I was amazed at the quiet streets, and unsettled at the spartan shops, the empty shelves, the dreary décor, the bomb damage from World War II still visible in the skeletal roofs of some apartment blocks. I remember a barber shop: dusty, bleak and austere. On the shelves surrounding the mirror were two or three pieces of soap: that was all the barber could offer, other than haircuts. It was not until much later that I learned that it could have been somewhat of a miracle that anything showed up on his shelves. An East German factory might have had two important

employees who were not actually on the official organisational chart. One was a 'jack-of-all-trades.' This unofficial employee was very smart at fixing stuff, at rigging and improvising solutions to keep machines running, to put together replacement parts, to correct problems in production. The second really important but unofficial employee was one who used factory money to buy and hoard stuff that could be used later (like the bars of soap in that barber shop). When push would come to shove, and the factory absolutely needed some spare part, or fuel, or other resource, then it could go out and trade these things (indeed, those bars of soap) against what it needed. Economists have estimated that if it weren't for these informal arrangements, and for the human ingenuity, resourcefulness, relationships and social networks, then a planned economy would not have worked at all. Nothing much might have been produced.

The example may be stark, but it's actually something that happens all over the world— wherever people work. And it is something that is not limited to one system of governance. The issue is that the world in which we work is non-deterministic: it is complex, unpredictable. It creates all kinds of side-effects and novelties that we might not have anticipated. We can try to nail that world down, to reduce it and lock it

> Work gets done because of people's effective informal understandings, their interpretations, their innovations and improvisations outside those rules.

in a box, but it won't ever be successful. The easiest way to make sense of this is of course the topic of this issue of Hindsight: we separate 'work-as-done' from 'work-as-imagined'.

Sure, we can imagine work in a particular way. We can believe that people will use the technologies we provide them in the way they were intended. Or that they will apply the procedure every time it is applicable. Or that the checklist will be used. These assumptions (hopes, dreams, imaginings), are of course at quite a distance from how that work actually gets done on the front line, at the sharp end. Actual work process in any air traffic control centre, or tower, or office, on construction site, or factory (whether once in East Germany or anywhere else) cannot be explained by the rules that govern it – however many of those rules we write. Work gets done because of people's effective informal understandings, their interpretations, their innovations and improvisations outside those rules.

For some, if there is a gap between how work is imagined and how it is actually done, then this is merely a shortcoming in how we manage and supervise and sanction people. We simply need to try harder to press that complex world into that box, to make it fit. Early on in the twentieth century, Frederick Taylor's 'scientific management' attacked work in exactly this way. It decomposed tasks into the smallest bits. It emptied them of meaning or interpretation, until there was nothing left to imagine. All there was, was work to be done. The ambition of 'scientific management' was to perfectly complete the world of work. No gaps; no stuff left unmanaged, no stuff unseen, nothing misunderstood. Everything pre-specified, proceduralised, checklisted, nailed down and choreographed in advance. The way work was imagined by the managers and planners, was the way

it was done – or to be done, precisely – by the workers. Layers of supervisors would see to that: it was primarily their job to close the gap.

As Erik Hollnagel notes in this issue, the Francophone tradition has long acknowledged the difference between tâche and activité. Roughly translated, this is the difference between (prescribed) task, or what is to be done, and (actual) activity, or what is done. The gap is not only implicitly acknowledged in the two separate terms; this tradition of studying work acknowledges that the gap can be large, and that it takes mutuality of understanding to make it smaller (if that is indeed the goal). If ever there is doubt about the existence of at least these two worlds of work – the official, rule-driven one and the vernacular – then one place to look is so-called work-to-rule strikes. These exploit the gap, of course. Air traffic control is not alone, and not the first workplace in which this has ever been done. Taxi drivers of Paris, instead of striking, have long resorted to what is known as a greve de zele. Drivers would all, by agreement and on cue, suddenly begin to follow all the regulations in the code routier. As was meant to, this would bring traffic in Paris to a grinding halt. Paris traffic only works when not everybody follows the rules.

A Spanish train driver recently showed how strict application of standardised rules can literally bring a system to a stand-still. Driving a train between Santander and Madrid in 2016, he decided to get out during a stopover in Osorno in the province of Palencia. Leaving 109 befuddled passengers behind in the stranded train, he simply walked away. What was his reasoning? He had long exceeded his duty time limits, violating not only his employment contract and transport regulations, but also health and safety rules. So he stopped working, in strict compliance with all the rules. The response of RENFE, the train company, was that this was a truly exceptional case. Most train drivers wouldn't do this because they have 'a healthy common sense', they said in a statement. This implies that most train drivers routinely violate all those rules, with assent and appreciation from their employer – in the name of production and

throughput. Sounds familiar? RENFE did find a replacement driver to get the 109 passengers to their destination and also refunded their tickets in full.

Yet perhaps it takes Scandinavians to turn this realisation around on itself. If workers can apply strict rule following as a form of protest, then this has driven the authority in one country there to call it 'malicious compliance'. This is fascinating, of course. Workers could argue that they are (for once) fully obedient, that all they exhibit is complete rule-following behavior. It is compliance to the letter, and it leads to worker behavior exactly as it should supposedly be. Yet it is deemed malicious. It is, after all, intended not to finally make the system work, but to bring it to its knees. The Scandinavians wouldn't be fooled, evidently.

It's not the work as imagined that tells us interesting things about the system; it's the work as actually done – however hard it may be to get a good sense of what exactly that is (as Erik Hollnagel rightly points out). If it occasionally takes 'malicious compliance' to show how far the two are actually apart, then that is maybe for the better. It should make all of us realise how much humanity, how much innovation, how much dignity of daily improvisation and problem-solving goes into making even the most technologically sophisticated systems actually work. Only people can keep together the patchwork of imperfect technologies, production pressures, goal conflicts and resource constraints. Rules and procedures never can, and never will. Nor will tighter supervision or management of our work.

Then there is one more, vitally important, point to this. Understanding how daily success is created – how work is actually done – can help reveal where the next potential adverse outcome might come from. And it can do that much better than investigating the highly infrequent failure. The reason for that seems to be this. An organisation that has already achieved a pretty good

safety record evidently has got its known sources of risk under acceptable control. But the accidents that might still happen in these organisations are no longer preceded by the sorts of incidents that get formally flagged or reported. Instead, accidents are preceded by normal, daily, successful work. This will likely include the so-called 'workarounds' and daily frustrations, the improvisations and adaptations, the shortcuts, as well as the sometimes unworkable or unfindable tools, user-unfriendly technologies, computers that lock up, and the occasionally unreliable results or readings from various instruments and measurements. These things are typically not reported: they are just all part of getting daily work done despite an imperfect, non-deterministic world. It's all in the game. People have learned to live with it, work around it, and get things done.

Leaders need to learn about these things, because they tend to be the conditions that might ultimately show up in how their organisation could drift into failure. We can't obviously learn about these conditions if we threaten with sanctions when not all the rules are followed precisely. That will shut people up for as long as we are there: they'll temporarily halt the workarounds and little innovations and improvisations which normally get stuff done. To learn how work is actually done – as opposed to how we think it is done – our leaders need to take their time. They need to use their ears more than their mouths. They need to ask us what we need; not tell us what to do. Ultimately, to understand how work actually gets done, they need an open mind, and a big heart. S

> Only people can keep together the patchwork of imperfect technologies, production pressures, goal conflicts and resource constraints. Rules and procedures never can, and never will.

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CAN WE EVER IMAGINE
HOW WORK IS DONE?

The terms 'work-as-imagined' and 'work-as-done' help to convey that the way that people think about work and the way that work is actually done are not necessarily the same. There are several reasons for this. In this article, **Erik Hollnagel** explores the dichotomy and questions our assumptions about work.

KEY POINTS

1. **Work-as-imagined (WAI) refers to the various assumptions, explicit or implicit, that people have about how their or others' work should be done.**

2. **Work-as-done (WAD) refers to how something is actually done, either in a specific case or routinely.**

3. **There is a difference between how work is 'imagined' or thought of and how work is actually done. This may or may not be problematic.**

4. **The solution to the gap is to try to understand what determines how work is done and to find effective ways of managing that to keep the variability of WAD within acceptable limits.**

Two terms that frequently crop up in contemporary approaches to safety and to work management in general are Work-as-Imagined (WAI) and Work-as-Done (WAD). They also played an important role in the initial discussions about resilience engineering, as described by Dekker (2006), although the origin can be found much earlier in the French ergonomics tradition (Ombredane & Faverge, 1955).

The meaning of the two terms is – hopefully – obvious. WAI refers to the various assumptions, explicit or implicit, that people have about how work should be done. WAD refers to (descriptions of) how something is actually done, either in a specific case or routinely. There are two main reasons why the terms were adopted in the first place, and why they have become widely used since.

First of all the WAI-WAD dichotomy makes clear that there is a difference between how work is 'imagined' or thought of and how work is actually done. The need to think about how work should be done is found everywhere (cf., Figure 1). There is inevitably a practical need to 'imagine' or think about how work should be done either when trying to improve existing conditions and approaches – often as

Design
(tools, roles, environment)

Work-As-Imagined

Work & production planning
("lean"- optimisation)

Work-As-Imagined

**Safety management,
investigations & auditing**

Work-As-Imagined
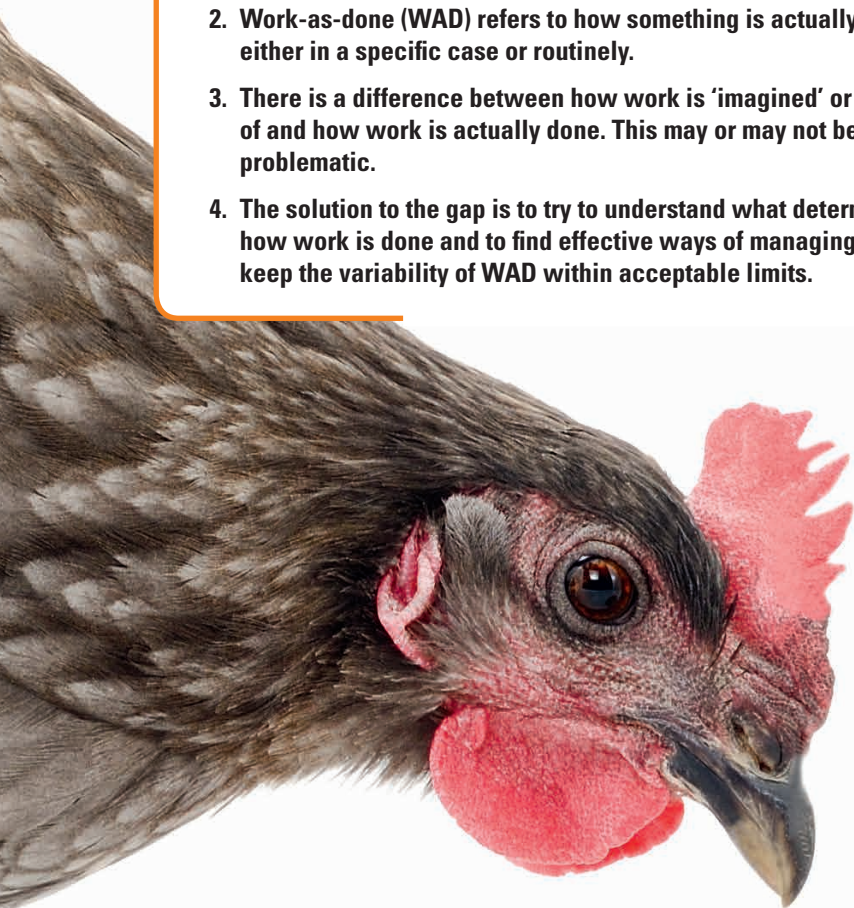
Work-As-Done

Figure 1: Work-as-Imagined and Work-as-Done

the result of an accident investigation – or when contemplating new ways of working, including the design of equipment and tools. Design, as David Woods has pointed out, is indeed "telling stories about the future" (Roesler et al., 2001). And telling stories about what may happen in the future requires imagination.

There is also a practical need to think about how work should be done as part of managing and scheduling operations and activities, e.g., to ensure that the right people are on the job or to meet the expectations of customers and clients. And there is finally a need to think about how work should have been done when events are being analysed – which usually means some kind of incident or accident investigation. Unfortunately, this often regresses to inventing stories about the past or proposing explanations in terms of contra-factual conditionals – such as "if only they had done X, then Y would no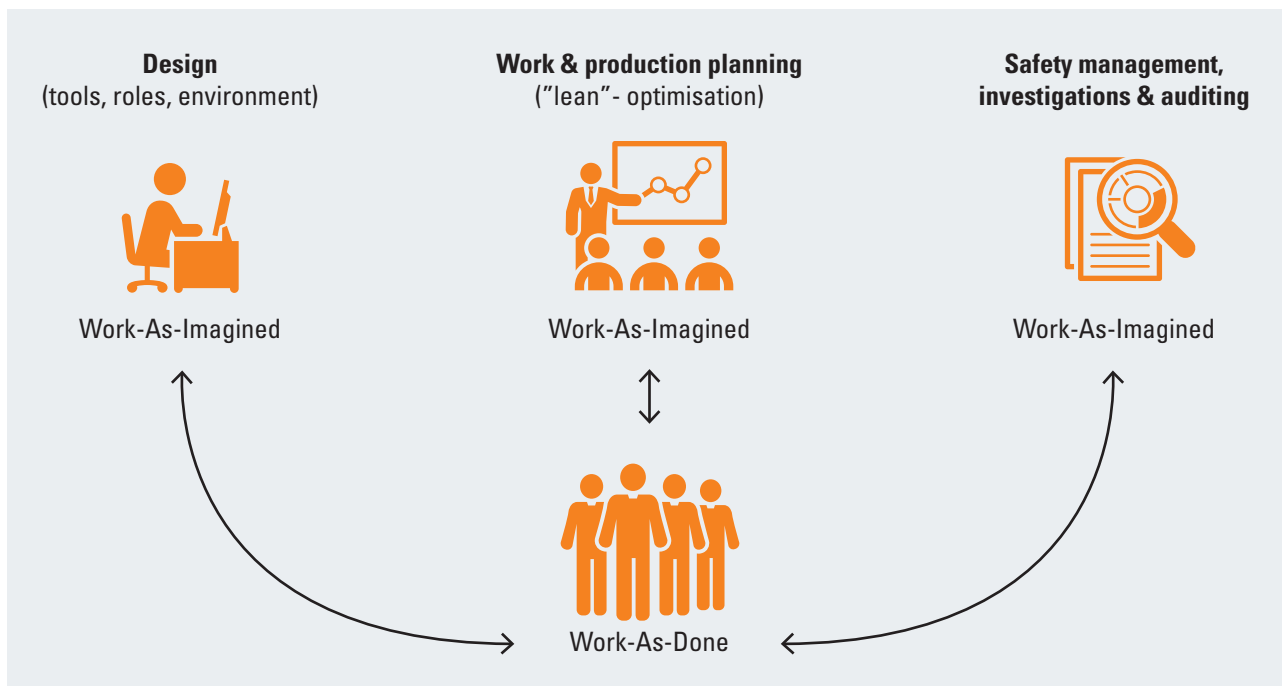t have happened". From a Safety-II perspective it is regrettable that the need to explain and understand WAD when something has gone wrong is so obvious and in many cases even mandatory, while it is practically non-existent when something has just worked as it should.

Secondly, the use of the terms can be seen as the (tacit) acceptance that it is impossible, in practice as well as in principle, precisely to prescribe how work should be done. This is because a precondition of WAI is another kind of "WAI", namely the "World-as-Imagined", i.e., the conditions that are supposed to exist for the work under consideration. It is often taken for granted that the working conditions are known and that they can be controlled within narrow limits. This condition may be approached in highly regular activities where even small discrepancies are economically unacceptable – chip production, pharmaceuticals – but even here there must be an acceptable return on the considerable cost needed to make compliance possible. Similar conditions are unattainable and perhaps even undesirable in most other industries, including aviation and ATM.

The WAI-WAD dichotomy appears to force the question of whether one is right and the other is wrong. (The question is misleading, but is asked nevertheless.) Historically, the answer has been that WAI was right and WAD was wrong, not in the sense that WAD represented errors or failures but in the

> It is impossible, in practice as well as in principle, precisely to prescribe how work should be done.

sense that it represented a less effective way of doing something. This meaning can be found in the 'work studies' of old, also known as Taylorism or Scientific Management, as well as in modern versions of quality management and 'Lean' as found in manufacturing, and increasingly in service industries, including health care. But focusing mainly on the differences between WAI and WAD, and taking for granted that WAI is correct, embraces a Safety-I perspective (Hollnagel et al., 2013). By focusing on the differences, one also focuses on the deviations – since only differences in one direction usually are noticed. This first of all presumes that we can treat the events as being discrete, when in fact they are always continuous. It also presumes that we can look at them sequentially (as individual steps or components), in accordance with traditional linear thinking.

Egocentric and allocentric WAI-WAD

Although WAI and WAD sometimes are used polemically to confront "them and "us" – the blunt end and the sharp end – this is not the only important
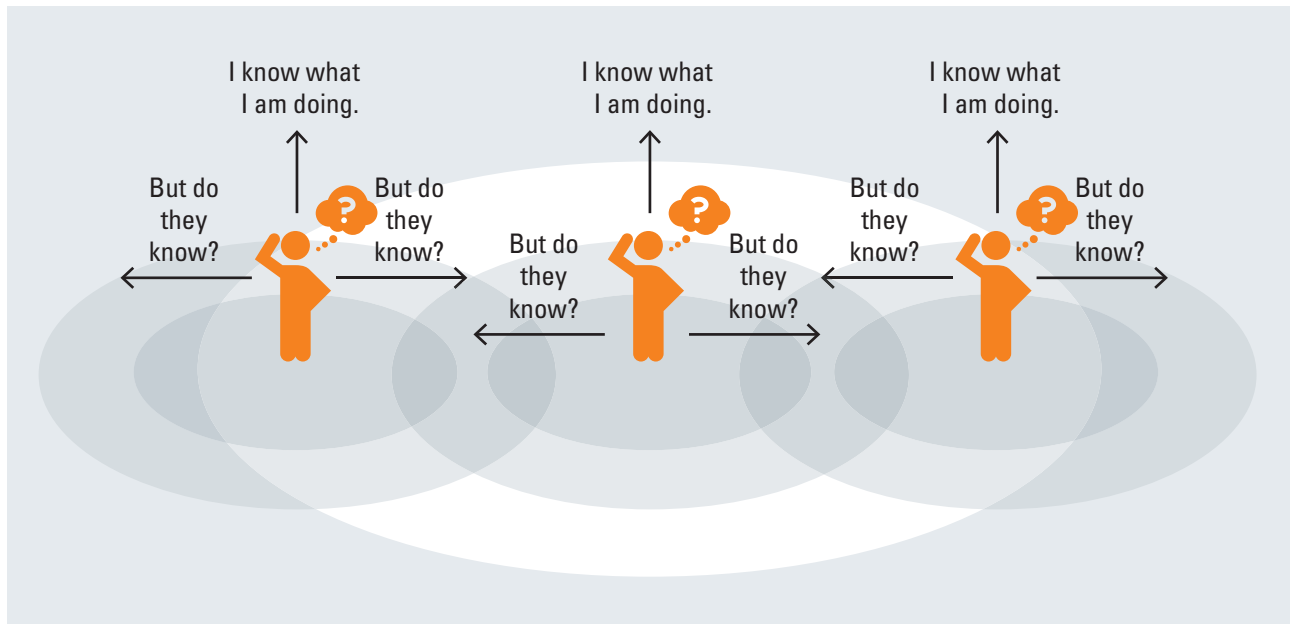
Figure 2: Egocentric and allocentric WAI-WAD

distinction. Equally important, if not more so, is the distinction between egocentric and allocentric WAI (cf., Figure 2). The former refers to the assumptions that people have about their own work, what they plan to do and how. When we begin work in the morning, for instance, we obviously have an idea about what we should have accomplished by the end of the day and how we should go about it. But we also know that it often may end up differently. The differences that occur in egocentric WAI-WAD are, however, usually easy to reconcile because WAI and WAD are connected in space and time. A mismatch can therefore quickly be noticed and used to revise either the expectations (WAI) or adjust the actual work (WAD).

Allocentric WAI refers to situations where WAI and WAD are separated by space and time. (Allocentric means 'concerned with others more than oneself'.) It is allocentric because WAI is not about what people do themselves but about what others do; plans and procedures are typically developed away from the actual place of work and by people who do not have up-to-date knowledge about how everyday activities take place. Allocentric WAI-WAD corresponds to the commonly

used distinction between the blunt end and the sharp end. The problem is, however, not just the polemic clash between the two 'ends', but rather that it is practically impossible to predict or describe how work that is done by others, at a different time and in a different place, will unfold in practice.

> Safety management must correspond to Work-As-Done and not rely on Work-As-Imagined.

In such cases there are neither possibilities for feedback, revisions, and adjustments, nor many opportunities for learning. People at the (relative) blunt end undoubtedly do their best to imagine or understand what Work-as-Done – and the "World-as-Is" – will be like. But their job is often made difficult by a lack of time as well as by incomplete, delayed and partly obsolete information. Because the world at the sharp end is a 'blooming, buzzing confusion' made up of countless, interconnected systems, the blunt end must try to make ends meet by relying on approximate adjustments in their reasoning.

WAI and the Zero Accident Vision

Safety-I tacitly assumes that work can be completely analysed and prescribed and that Work-As-Imagined therefore will correspond to Work-As-Done. A good example of that is the Zero Accident Vision (ZAV), which has been

expressed as follows: "ZAV is based on a belief that all accidents are preventable. If accidents are not preventable right away, then this should be feasible in the longer run. The aim of ZAV is to encourage people to think and act in a manner that supports the vision that all accidents are preventable." (Zwetsloot et al., 2013). One tenet of the ZAV is the insistence on "simple and non-negotiable standards" – in other words that it is possible to define and enforce a common, simple set of standards that guarantees that work will be perfect.

But the more intractable environments that we have today means that Work-As-Done will differ significantly from Work-As-Imagined. Since Work-As-Done by definition reflects the reality that people have to deal with, the unavoidable conclusion is that our notions about Work-As-Imagined are inadequate if not directly misleading. This constitutes a challenge to the models and methods that comprise the mainstream of safety engineering, human factors, and ergonomics. It also challenges traditional managerial authority. Safety management must correspond to Work-As-Done and not rely on Work-As-Imagined. Safety-I begins by asking why things go wrong and then tries to find the assumed causes to make sure that it does not happen again – it tries to re-establish Work-As-Imagined. The alternative is to ask why things go right (or why nothing goes wrong), and

then try to make sure that this happens again. A practical implication of this is that we can only improve safety if we get out from behind our desks, out of meetings, and into operational environments with operational people.

Can we ever imagine how work is done?

Returning to the question that serves as the title of this note, the answer is the typical human factors reply of "Yes, but …". The answer is on the one hand affirmative, because we certainly can imagine how work is (to be) done if we try, especially if we pay attention

to what actually happens instead of relying on what we imagine should happen or should have happened. On the other hand, the provisory "but" signifies that we should not expect ever to achieve a perfect match. The solution is neither to force WAD to comply with WAI – as in the ZAV and Lean – nor to modify WAI so that it corresponds to WAD. Work-as-Done is a moving target because working conditions, demands, and resources rarely are stable. The solution is rather to try to understand what determines how work is done and to find effective ways of managing that to keep the variability of WAD within acceptable limits. The

way that work is actually shaped by the working conditions and environment is the best basis for making improvements as well as for identifying hazards. The difference between WAI and WAD should not be looked at simply as a problem that ought to be eliminated if at all possible. The difference should instead be seen as a source of information about how work is actually done and as an opportunity to improve work. **S**

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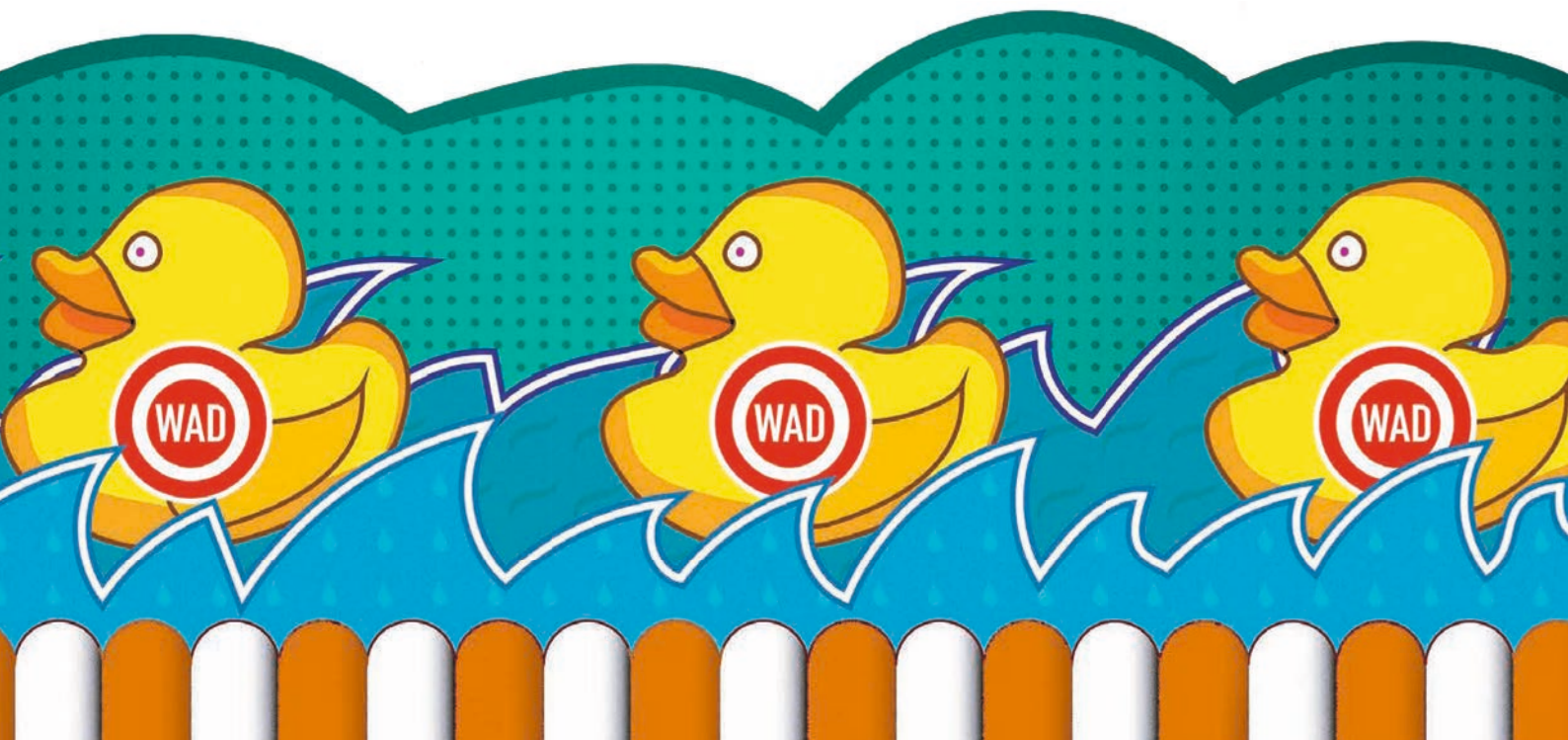
SAFETY IS IN THE EYE OF THE BEHOLDER
THE "PUT-YOURSELF-IN-OTHER'S-SHOES" CONCEPT FOR SAFETY CULTURE

Whenever we use the word 'safety', we tend to have our own ideas about what safety is. Some may be thinking more about the regulations and SMS, while others may be thinking more of the front-line human performance. Is it about one or the other, or both? In this article, **Florence-Marie Jegoux, Ludovic Mieusset, and Sébastien Follet** explore the question.

KEY POINTS

1. **Safety may not be achieved by just 'regulated safety'; 'adaptive safety' is essential.**

2. **Exchanges between different professionals help to fill the gap between work-as-imagined and work-as-done.**

3. **Trade-offs may be more accurate if we 'put ourselves in others' shoes', if we learn about their worlds.**

"What the heck, no need to push, he can do it on his own!" What a surprise, as ATCOs, to hear that coming from a marshaller at our airport.

What happened?

As ATCOs, we once had the opportunity to spend an afternoon with the ground crews at our airport. During that time, we experienced different types of push-back and autonomous departure according to the rules in force. At one point, during a very busy period, we were about to push back a CRJ7 on the edge of his CTOT on stand 3, when our tug was sent to another stand. It appeared that an ATR42 on stand 1, which should have departed well before, had to depart right away. The consequences of this mess: for the ATR42, a delay; for the CRJ7, a missed CTOT. Both resulted in missed connections for their passengers. It appeared that due to the high level of activity, there was a lack of tugs.

Considering his objectives and his constraints, the marshaller had decided to prioritise the departure of the ATR42 for the good of the passengers and the company. He suggested to the pilot to ask the controller for an autonomous departure. It was not acceptable regarding the rules in force for this stand, and thus it was refused.

What does this show?

Undoubtedly, there is a difference between the work-as-prescribed and the work-as-done. Let's go back to the process of implementing this very rule. On one hand, in order to implement safety on the departure of airplanes from the terminal, airport managers, handling company managers, and ATC managers imagined the work as it has to be done and prescribed some rules. They defined a so-called regulated safety (see Figure 1). On the other hand, the ground operator, confronted by the lack of means and the operational aim of the company (no delay) had to find a solution. He took into account what he imagined to be the spirit of the rule; who wrote it and for what

Regulated Safety	Adaptive Safety
Building safety via rules and norms in anticipation of situations. Legal requirements are written to ensure safety.	Producing safety by giving responsive answers to situations. This represents adaptive intelligence from professionals.

Safety = Regulated + Adaptive Safety (see Morel, et al, 2008)

Figure 1: Regulated Safety and Adaptive Safety

purpose. With this picture in mind, he made a trade-off and did his work the best he could. As with all operators, his strategy was to implement the best safety according to the immediate situation. This defined a so-called adaptive safety.

Generally, when a new situation arises, managers from different sectors gather to determine undesirable events and risk mitigation. They rely on their perception of the situation; their conception of their operators' work.

This is work-as-imagined. Based on this, they write some rules, which is considered as work-as-prescribed. What happens if the work-as-imagined is different from the work really done? Operators have to solve immediate safety situations. They try to work as prescribed as much as possible. However, when there is no pertinent answer, they have to imagine the work done by those who wrote the rule in order to adapt it in the best way.

What happens if their perception of the managers' work is different from the work they really do?

Indeed, there is a difference between work-as-prescribed and work-as-done. Each side imagining the way the other works creates a gap.

What are the consequences?

First, managers and operators are following their own safety path. Each one tends to implement safety, but the two sides do not always practice the same kind of safety. Indeed, one side will apply regulated safety, while the other will stick to adaptive safety. This may lead to misunderstandings, frustration, and loss of confidence amongst co-workers. Furthermore, this situation may create a rift in the global safety of the system. Ultimately, this may result in a ludicrous situation where the managers write more and more rules, while the operators apply them less and less.

Second, if the managers of the airlines, ATC and airport companies are sharing their points of view and write some rules together more and more frequently, this is still not the case between operators. So, even when there is a common prescribed work given to operators, the work done does not always converge. Operators can share a common point of view and deal collectively with the situation. But this is not always the case. They have different points of view, situation awareness, objectives, and constraints. The imagined solutions often differ significantly, and the work done is not always what others expect. These differences could lead to misunderstandings, conflicts, prejudices, and safety events. The best way to figure this out is to imagine a system where the work done by each operator is like a pendulum (see Figure 2). The movement of the pendulum is influenced by the context, the constraints, the objectives, the pressure, and other similar influences. Depending on these conditions, operators share a common work-as-done, or not.

This mechanism can be found in many situations when two parts or more are engaged on a common task. What about the guidance of airplanes on approach? We share a common prescribed work between pilots and controllers. We have the same rules for ILS interception, for example. But what is really done? Sometimes, pilots or controllers shorten the approach. According to the context, the constraints, the objectives, and the pressure, a pilot may try to shorten his or her route even if it's not in standard stabilised approach rules. What if it doesn't match with the vectoring or the sequence the controller is doing? We can easily imagine that pilots have the same kinds of examples about controllers. Relying only on imagination to understand the other side leads to misinterpretations and misunderstandings. This explains why pilots often don't understand why controllers ask for speed reductions very far from the arrival airfield, or why they give descent step by step.

Indeed, as ATCOs, we have endless examples like this about the difference between the actions of pilots and controllers: speed reductions, radar vectors or approximate fly-over points are further examples. It could be between controllers of two different control centers, approach or ACC, civil or military, between marshallers and pilots, between fire services and ground controllers, between bird scaring services and pilots or controllers, between engineers/technicians and pilots or controllers, UAV operators and controllers, etc. The list will expand as long as different operators have to work together.
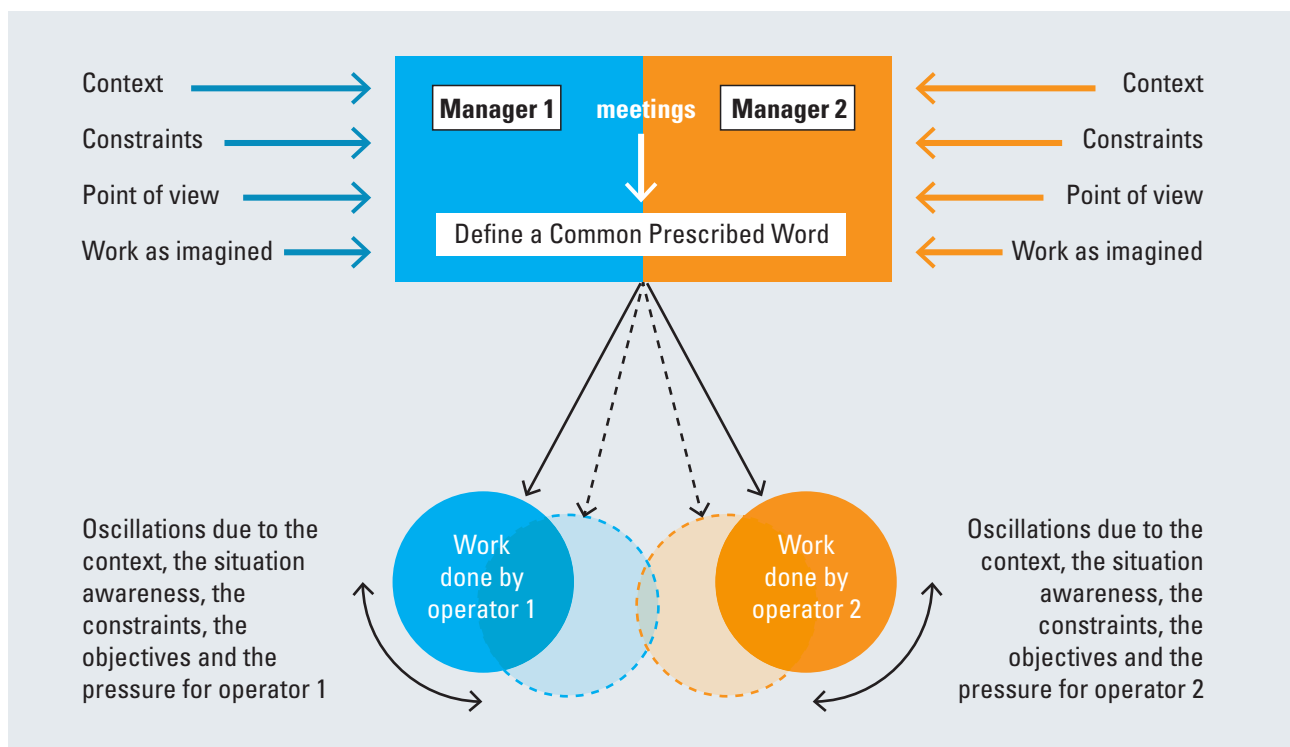

Figure 2: The pendulum of the work done by operators

What are the solutions?

First, fill the gap! Filling the gap between reality and imagination could be a way for regulated safety and adaptive safety to converge. For this to work, every concerned party will have to explain in detail all the details of their jobs. There is a real need to understand what the others do.

In the ultra-safe system of aviation, regulated safety might seem to be sufficient. However, it's utopic, as there will always remain some chain of unexpected events leading to situations that will fall outside the parameters prescribed by the rules. Rules have to be adaptable to most situations. They must take into account the reality of work-as-done. It is not sufficient anymore for managers to rely on what they imagine the operators do. To achieve the next safety step, they have to look at what is really done, and understand operational trade-offs. For managers, sharing time with operators will help them to move from a deficient perception of the work to a more enriched and accurate one.

If managers have to understand what operators do, the reverse is also true. To fully understand the spirit or the rules, operators have to meet up with managers and understand their jobs. Sharing time with managers will help operators to move from a deficient perception of the prescribed work to a more enriched and accurate one.

With a clear, curious, honest, benevolent and open-minded view between operators and managers, prescribed work will be more operational and interpreting and implementing rules will be more effective.

The solutions suggested above solve only one part of the problem: the differences between work-as-prescribed and work-as-done in the same company. What about the differences between work-as-done involving two different operators? The same recipe of sharing, sharing, and sharing even more can be used to fill the gap. As shown in the first example of this paper, as ATCOs we sometimes get the opportunity to go on the field, meet other operators, discuss and share their environment, their point of view, their objectives, their constraints, their experience; the essence of their jobs. This benefits safety because it gives the opportunity for operators to get closer to their problems and to find trade-offs that are operational and acceptable for both sides. It benefits relationships because very often we speak through a radio or a telephone and sometimes via someone else.

We have been organising meetings between pilots and controllers as part of our HF training for over eight years now. Additionally, we have been attending their CRM training. It has helped a lot in resolving misunderstandings and created long-lasting friendships that enlarge our perception of professional situations. We are now more prone to give the benefit of the doubt when conflict arises rather than grumpily venting on the frequency.

To improve adaptive safety, we must play as a whole team. Instead of each individual operator trying to improve safety, all operators must build safety together. To get a chance to do it together, we have to know each other, and we have to communicate face to face.

The concept of 'putting yourself in another's shoes', could seem unimportant when we're talking about safety, but it seems to be a key point to make regulated and adaptive safety more efficient. It will help to fill the gap between work-as-prescribed and work-as-done, and between the different work done in specific situations. As operators, we urge the implementation of these exchanges. ↻

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Florence-Marie Jegoux became a certified air traffic controller in 2004, working for the French Civil Aviation Authority (DGAC), in the Air Traffic Service provider of Western France. She then has been working as a Human Factors coordinator and specialist for their training department for the last 8 years. Florence-Marie also works for the French HF National Group and is trained in systems theory. She is a private pilot.

Ludovic Mieusset has been an Air Traffic Controller for the last 26 years. He began as a French Air Force ATC on a fighter jet Air Base. After 11 years, he joined the French DGAC and became a Tower Controller in busy General Aviation airfields near Paris and Grenoble (French Alps). This aviation enthusiast is now an ATCO and HF Facilitator – among other aviation related activities – at Rennes Airport (West of France).

Sébastien Follet has been working as an Air Traffic Controller for the last 15 years. He is also a HF facilitator for controllers in his ANSP. Formerly in Paris-Le Bourget airport, he is currently working in Nantes airport. In Paris, he has worked on various safety studies to implement new equipment. He has a degree in Ergonomics & HF Basics from Paris Descartes University. This aviation enthusiast has been a private pilot for 15 years.

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In order to become a trainee controller, you will need to fill out an application form and pass a pre-employment aptitude test. But first, make sure that you fulfil all of the entry requirements. All applicants must be a national of one of our Member States and be younger than 25 at the start of the training. Furthermore, you should have completed your secondary education at an advanced level, with mathematics as one of your subjects, and be free from any military service obligation at the start of the training.

Do you meet all of these requirements? Great! Go ahead and fill out the application form. If you are suitable, you will be invited to our Maastricht centre for testing and interview.

The selection procedure is made up of several phases. First, you will be tested on your basic skills such as logical reasoning, memory, and spatial orientation.

The second phase tests how well you apply those skills in working conditions. You will be assessed on your stress resistance and multitasking abilities. After this, you will be given a personality questionnaire to complete, and you will be interviewed about your experience, motivation and expectations.

The hiring process for trainee controllers is rigorous and detailed. It is designed to select the most qualified applicants. However, do not let this put you off from applying. A positive, determined and open attitude will take you a long way. After you have successfully completed the selection procedure, you will be allowed to start training as an Ab Initio Air Traffic Controller with EUROCONTROL. Exciting, right?

TRAINING FOR THE JOB

Training to be an air traffic controller takes between two and a half and three years. Courses start in February and October each year; they are entirely taught in English and include theoretical classes, simulator training and intensive professional training.

The Basic Training takes place at the National School of Civil Aviation (ENAC) in Toulouse, France. The range of theoretical topics is highly diverse; from navigation, telecommunications, and aerodynamics, to air traffic services and aviation law.

The theoretical training is immediately followed by the Unit Training at the Maastricht Upper Area Control Centre (MUAC). This Training is divided into different phases: Pre-Transition Training, Pre-On-The-Job Training and On-The-Job Training. During the Pre-Transition Training, you will learn more about the detailed airspace of the sector group you will be trained for. The Pre-On-The-Job Training concentrates on different aspects of the work as an Air Traffic Control Officer, and consists mainly of simulator training. During the last phase of the Unit Training, the On-The-Job Training, you will train on live air traffic control positions in the MUAC Operations Room under the supervision of a dedicated instructor If you have successfully completed both the Basic and Unit Training, you will be a fully qualified Air Traffic Control Officer.

BUILDING A CAREER

Let's take a look at just a few of the career opportunities open to you. If you want, you may spend your whole career as an operational controller. Alternatively, you might consider utilizing your acquired operational experience in another field. You could become a professional trainer, a safety expert, or an experienced operational support to development projects in various fields related to air traffic control.
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IMPROVING RUNWAY OPERATIONS
FROM A CAR PARK

The way that we adapt to our environment in everyday life can teach us about how we do this at work. In this article, **Sebastian Daeunert** describes how Frankfurt tower contemplated changes to runway operations, ultimately giving controllers responsibility for their way of working.

KEY LEARNING POINTS

1. **It is up to us to put safety and human factors theory into practice.**

2. **Too much reliance on rules can have a bad effect on our sense of responsibility.**

3. **We need to adapt how we work to how things work. Involving sharp end operators in the design of work is the way to improve work.**

Every morning when I go to work to our control tower at Frankfurt Airport, I park my car on the fifth floor of the staff car park. Instead of taking the long official way across a bridge, over the road, then back via a traffic light crossing the road again, I save 10 minutes by taking the back-door staircase. Everybody I know does this.

This means taking a staircase leading to the ramp that is part of the entry road, then through the gate area of the car park, and finally dashing over the entry area. It requires balancing on a narrow ledge that is officially not a pedestrian walkway, with buses and trucks passing within inches at speed. Drivers blow their horns at the dark figures crawling underneath the barriers in the darkness of the early morning. It's pretty scary at times.

I like to present this case as an example of work-as-done vs work-as-imagined to my ATCOs in my safety briefings.

Why? Because it has a happy ending. Last year, the airport operator did something wonderful. Instead of locking up the door of the backdoor staircase, or putting up a fence blocking the path, they simply added an official wide pavement walkway with a red and white protective fence facing the road. There even is lighting, making the dark figures of the early morning clearly visible to the drivers of the cars on the other side of the fence. Now everyone can take the little 'secret walkway' officially and safely.

Isn't this how it should be? Put your ear to the operation. When you see a deviation, interview the operators and then adapt the system to it, so that everyone can do it safely and according to a common standard.

When I was at a EUROCONTROL human factors conference in Lisbon in 2015, reviewing the slides for my presentation (everyone else was sightseeing in Lisbon), I finished early and a thought came to my mind.

What good are all these ideas and thoughts if we don't use them in real life. As interesting as they may be, there is always a danger of us ending up in that famous ivory tower ourselves. Already I was scribbling on my notepad, ideas pouring from my head, how to adapt those interesting ideas to our airport in Frankfurt. And I soon realised: all these ideas are definitely adaptable to real life.

Were we not making too many rules? Was this not the feedback I received from my ATCOs, that they felt they had no decision power anymore because everything was prescribed? Were these not the complaints I heard, that too many outsiders were governing their work in a very destructive and complex manner? Politicians, noise abaters, rule-makers and yes even us – the safety people.

I was wondering if we should not make new in-roads to the way we are dealing with our rules. It turned out to be nothing less than a complete culture change in our local administration.

The plan was to help our ATCOs reclaim that important sense of responsibility, which goes hand-in-hand with behaving responsibly.

After initial rather irritated reactions by local management, they quickly started to get into discussions with me and then agreed to put this on a broader base, working together with our central safety management. Thanks to that we soon had Prof. Woods doing workshops at our tower followed by a EUROCONTROL Regional Conference. Our base had just grown so much wider.

We started to get to work. My initially irritated bosses soon became fans and strong supporters of the idea, seeing the benefits of it. Without that it would have been dead before it started.

In Germany we have a saying: "To cut off old beards", meaning getting rid of things that have always been there but nobody really knows why. We reviewed several procedures that were seen by our controllers as annoying and found out that some of them had no reason other than "It has always been done this way". We deleted them, turning some of our controllers heads ("They really mean it!") with very little effort.

We continued towards the harder stuff, the holy grail of operating our airport. Should controllers be allowed to work both Runways 25L/C from one working position if traffic allows?

What is behind this is that RWY25L is used for landings, runway 25C for departures. Inbound aircraft taxi towards RWY 25C, hold there, are then sent to the departure RWY25C controller for crossing and then to Apron. This additional frequency change is seen as a nuisance by many controllers, but is necessary as two controllers may not operate one runway on different frequencies.

When there is a missed approach a lot of coordination has to be done, thanks to an environmentally-inspired departure route, which crosses in front of the end of RWY25L. This has led to misunderstandings in the past and adds complexity. When there is little or medium traffic, so the argument of some of our controllers goes, a lot of complexity could be avoided by working both runways from one position: "It is easier to coordinate with myself in my own head" one of them said.

The other side says that workload increases with the number of planes on the frequency. Add this to existing complexity and it may be a danger.

This had been subject to heated emotional discussions and the final and never-to-be-discussed-again outcome: one controller, one runway!

"I was bred to be a race horse and now they make me plough the field", one

disappointed controller had written. Still, there was the silent majority, wasn't there? Those who approved but wouldn't say so?

Things had quietened down. To my knowledge though, more and more controllers were simply disobeying the rules and keeping aircraft on their frequencies for the runway crossing anyway. To me this represented a danger: while some were doing it, others weren't. And each one doing it was doing it in a different way.

Should we really open that can of worms again? Stir up all the dust that had so comfortably settled? We decided yes. By now we all had agreed that to follow operations and constantly evaluate what the 'sharp end' is doing is the only way to go. Even if it is painful, there is no other way.

We invited a group of 10 controllers to a meeting; a good mix of those for and against runway consolidation (there seemed to be no middle group). The meeting showed that it is sometimes hard to break old habits and you consciously have to force yourself towards the new. The initial approach was to put airport traffic graphs on the wall, hour by hour and to extract a complex set of rules at which minute what runways can be worked in unison. If followed through, a complex algorithm of 'When? What? Where?' might have resulted. Quickly, this idea was abandoned.

We have highly trained, professional controllers, whom we rightfully demand to behave in a responsible manner. Can these people not decide by themselves when to work runways in unison, and when not? Do we really have to make rules?

After several meetings we came up with the idea of an extended trial (one year) where we give a recommendation regarding the traffic load but leave the decision in our controllers' hands.

A safety assessment has been made before the trial and we will be starting it shortly.

My personal feeling is that when we hand back responsibility to our controllers, they act responsibly. Responsibility means the freedom to make decisions but also the need to be held responsible for them. This is to me the core function of any controller. It is also the reason we are so proud of our job.
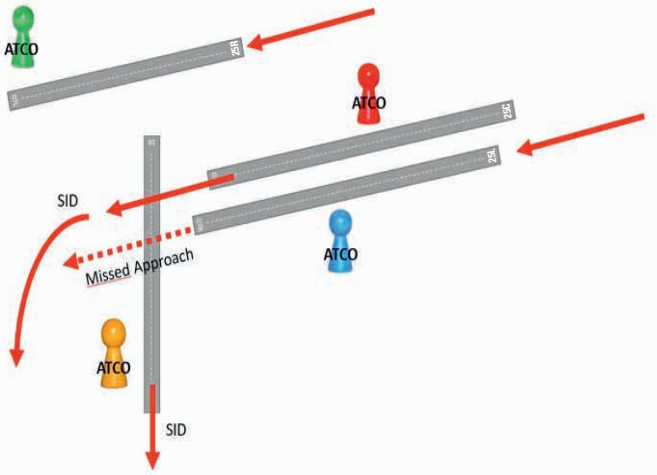
To encourage responsibility means to have people who enjoy their work but also do everything in their power to do a responsible and safe job. It is a high motivation. Taking away responsibility means conditioning people to become mere accessories to a set of rules, who will just do as they are told, but have no relationship to what they are doing. They will become bored, irresponsible and eventually break the rules.

By seeing our controllers as resources and not as a danger that has to be contained in order to make our system safe, we keep the quality and satisfaction of everyone up. For management this initially means a leap of faith in their direction. However, the result is a better, safer system.

This in my view was only achieved by looking at work-as-done and adapting work-as imagined.

This does not mean that anything goes. If you see people crossing a high-speed Intercity express railway line you may well have to stop them initially because there could be casualties. But in the long run the question must be: "Why are they crossing it when they know it is dangerous?". The solution may be a pedestrian bridge over the railroad tracks or, like in the case of our car park, a safety fence with a brightly lit pedestrian walkway. 5

Sebastian Daeunert is the incident investigator of Frankfurt Tower. He was an active TWR/APP controller for 15 years before getting into safety management and human factors. He participates in the EUROCONTROL/ IFATCA Prosecutor Expert scheme.

CAN COMPETENCE ASSESSMENT
BE USED TO UNDERSTAND NORMAL WORK?

Competence assessment is one method for checking that work-as-done accords with work-as-imagined. In reality, it is often the case that work-as-done is temporarily shifted to realign with work-as-imagined. **Anne-Mette Petri and Anthony Smoker** argue that changes to the competence model may be needed if we are to understand competence from a systems perspective in the context of work-as-done.

"If a controller can produce a dull normal day, that should earn recognition and praise because the controller had to change to achieve that outcome."
(Weick, 1987)

Competence assessment has for many years been a routine feature of operational assurance within European ATM. Traditionally, the focus has been on monitoring and identifying non-standard performance due to errors in technique as well as procedural non-compliance. One problem with this approach is that it does not explain why and how ATC normally works well. Another concern is that an annual one or two-hour assessment of competence gives an artificial view of individual performance: a bit like setting up a one-day speed camera, once a year.

Understanding the 'why' and the 'how' of ordinary work cannot be attained by judging performance through a narrow normative lens where the operational task is exclusively defined by rules, procedures and the adherence to these. The scope of what is defined as competence needs to grow beyond the traditional ESARR 5 definition where competence is solely described as "the required level of knowledge, skills, experience and where required, proficiency in English, to permit the safe and efficient provision of ATM services." (ESARR 5, 2002, p.8). This definition is elusive and does not specify the various skills required to navigate normal work.

KEY LEARNING POINTS

1. **Competence assessment is a routine task and its usefulness is rarely questioned.**

2. **A once a year snapshot of idealised work cannot capture ordinary day-to-day work.**

3. **There is a need for calibrating the traditional view of competence to encompass the new functions of normal work.**

4. **An alternative competence model is proposed, along with ideas for an evolved assessment approach.**

We believe that the competence of operational practice cannot be defined by procedural compliance alone. Weick implies this in the quote above. The reality of a controller's normal work involves expertise in changing strategies and adapting to the variations that naturally occur in the controlling world.

> Controllers adapt to subtle variations in the traffic, trying to optimise efficiency, while keeping the sector safe as well as providing the best service possible.

This brings us to the challenge of a yearly dedicated check, which is perceived by operational staff as a temporary speed camera. A quite natural reaction when encountering a speed camera would be to revert automatically to a compliance-based simplification of work-as-imagined or work-as-prescribed. This is problematic since it will not give us insight into the uncertainty and variability experienced in normal work. Controllers adapt to subtle variations in the traffic, trying to optimise efficiency, while keeping the sector safe as well as providing the best service possible.

A Safety-II or work-as-done perspective of competence would be an exploration of the messy details of an imperfect world, of flawed information and uncertainties, and how this shapes work. From this we can trace competence back to:

1. How a function or an organisation interacts with others.
2. How it uses its capabilities to sustain an effective and safe operation to ensure that things go right.

Today the scope of the competence assessment scheme is focused on the individual alone and hence does not embrace or recognise these competencies.

Skill-based Competence

Knowledge-based Comeptence

Work-As-Imagined

Social Competence

ATCO

Esperience-based Competence

Service-driven Competence

Adaptive Comeptence

Work-As-Done

This was the starting point for an MSc research question, which essentially questioned if competence assessment of air traffic controllers can enable or facilitate a transition from Safety-I to Safety-II by recognising performance variability and adaptation (Hollnagel et al, 2013; Hollnagel, 2014).

A study was conducted in three European ANSPs. The three ATC units had different assessment philosophies and they applied different competence assessment methods. The aim was to examine the current practice of competence assessment of air traffic controllers, both as a concept and an operational process. The units were represented by a tower with 13 controllers, an approach unit with 50 controllers and an area control centre with 180 controllers. All 20 informants were directly or indirectly involved in the competence assessment scheme and were thus selected to represent air traffic controllers (ATCOs), competence assessors, managers and safety managers. Sixteen semi-structured interviews provided qualitative data for this research (four of these were conducted as small focus group interviews).

The study found a need for calibrating the traditional view of competence to encompass the many new functions of normal work. An enhanced six element competence model was derived from the research data to emphasise understanding of the daily activities of work. The six elements of the competence model are:

- Skill-based competence
- Knowledge-based competence
- Experience-based competence
- Adaptive competence
- Service-driven competence
- Social competence

The six-element competence model represents a synthesis of the ESARR 5 definition of competence and the data provided by the informants. The new model was adapted to include a view where work-as-imagined and work-as-done has relevance. The research has triggered a recognition that the scope of competence needs to broaden and recognise competencies

which otherwise will remain hidden or embedded in generic categories such as skill and experience.

In the current competence assessment scheme, emphasis is placed on work-as-imagined. The means of measurement are limited to skill-based competence during the practical part of the assessment. Knowledge-based competence is commonly assessed through theoretical examination in conjunction with the assessment. Both are assessed and measured against an imagined or prescribed view of work. Experience-based competence is not as tangible and is not measured or assessed per se. However, it is acknowledged that previous experience will provide you with a background to interpret and safely manage a given situation to ensure the best possible outcome.

The research found that working as an ATCO involves additional skills to those previously imagined. The new competence elements of adaptive competence and service-driven competence incorporate central aspects of Safety-II and are therefore placed in conjunction with work-as-done.

Adaptive competence comprises the need for flexibility and adaptability on an individual as well as a system level. These abilities were described by the participants as being core competencies and relate to the ATCO's 'discretionary space'. The introduction

of free route airspace was mentioned as a contributory factor in generating a stable condition of instability demanding both flexibility and adaptability of both the operator and the system.

Service-driven competence comprises trade-offs and the prerequisite of providing a high level of service, supporting flight efficiency or being able to work at a 'normal' speed. Being service-oriented – and providing a high and consistent level of service – appeared to be the driver for working efficiently and expeditiously. This again, is directly linked to social competence that embeds teamwork, cooperation, helpfulness and social skills.

Exploring these new key competencies is critical if we wish to gain a deeper understanding of what is 'normal' and what work really looks like when there is no speed camera.

Let's focus on, and talk about, normal work!

Is it then at all possible to measure adaptive, service-driven, social and experience-based competence? It could perhaps be feasible if we reduced these competencies down to specific behaviours, but it may not provide us with much understanding. It is, however, essential to find an appropriate method of exploring these new elements to understand work-as-done.

Controllers are adept at changing or adapting plans and tactical strategies to manage their workload.

The operational environment is always changing, so people constantly have to adjust. Controllers are adept at changing or adapting plans and tactical strategies to manage their workload. This is one of the main reasons why the four bottom competencies in the model cannot be viewed through a ruleset; they have to be explored through talking to people. Although some of the elements might not be observed during the practical part of the assessment, they should still be explored using focus topics and scenario-type questions. The purpose is not to measure or evaluate performance, it is more to gain an understanding of how and why ATCOs adjust their performance on a day-to-day basis. This, however, does not exclude the traditional assessment of the two top competencies.

Setting the scene for obtaining this kind of information is crucial for the ATCO to feel comfortable in disclosing information on how the system is behaving. An appropriate setting would be a debrief based upon the six-stage competence model, as this includes the perspective of the messy details of the operational world that requires flexibility, adaptability, efficiency and teamwork. Considering that these are features of work-as-done, they should be appreciated and understood as significant constituents of competence.

What does all this mean in practice? Competence in the future is more

than individual competence alone. The competence envelope has to expand to include how the system influences individual competence and how the individual contributes to the sustainability of the system.

Today and tomorrow

The reality of operational competence is changing. The current tradition of assessing procedural compliance by the individual air traffic controller is challenged in a dynamic socio-technical system such as ATM.

As operational needs change, technology advances and human-system integration increases, the nature of work will change. New skill patterns and competencies will emerge and the assessment must include these. To anticipate and monitor change, organisations must explore and understand dynamic patterns of expertise and adaptive strategies. These are informal and yet effective solutions that frequently go unnoticed.

Today, competence assessment is not used to the full extent possible and the original philosophy of the ESARR 5 scheme is becoming outdated. This research has shown that there are additional technical and professional controlling skills, which are part of everyday work, and competence assessment should be extended to include this.

Developing a competence assessment scheme that can monitor the successes and failures of normal work, in addition to the constantly changing gaps between work-as-imagined and work-as-done, will improve the organisation's ability to succeed under varying conditions. Moving from an individual to a system perspective will help improve the effectiveness of the ATM system as a whole.

There is still great potential in including the dynamics of the ATM system and understanding how controllers are able to produce a dull normal day, even within the philosophy of competence assessment. Pragmatically, considering the ability of the industry to embrace such a change, there needs to be an evolutionary path and not a revolutionary one. S

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Dr Anthony Smoker is a teaching assistant in the MSc programme in Human Factors and System Safety at Lund University, himself an alumni in the programme. He has completed two PhDs in the field of human factors. Anthony was a former controller and former Manager Operational Safety Strategy (NERL) at NATS, and is a member of the EASA Advisory Board for IFATCA.

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WORK AS DONE BY CONTROLLERS:
A PRACTICAL APPROACH IN THE OPS ROOM

When new technology is introduced, systems designers might imagine that users will use the technology in the same way. In practice, the design is not really finished on implementation, and the users 'finish' the design via their varied interactions and adaptations. In this article, **Guadalupe Cortés Obrero** explores how controllers at NATS use the iFACTS technology.

KEY LEARNING POINTS

1. Controllers adapt their use of iFACTS technology based on the different types of sectors, their experience of using it, and the benefits realised.

2. Controllers' acceptance and use of technology is driven by their mental model or understanding of it, the perceived understandability of the technology, the perceived benefits, and the technical behaviour of the system.

3. Training and the early interactions influence how controllers subsequently use technology.

4. The reactions of peers and instructors in relation to acceptance and use of technology influences acceptance and use.

How do controllers actually use advanced tools? For almost three weeks in April 2017, I had the opportunity to study how air traffic controllers at NATS' Swanwick Centre interacted with the iFACTS (interim Future Area Control Tools Support) system, an advanced automation decision-aiding tool.

iFACTS

iFACTS was introduced by NATS in 2011 to increase capacity and improve safety in en-route London Area Control airspace. The system supports the ATCOs' decision making by complementing the information provided by the radar system with support tools and visual aids. It calculates a predicted future position of an aircraft 18 minutes ahead using information in the flight plan route, controller-entered clearances, forecast meteorological data and aircraft performance data. iFACTS uses this information to predict and compare different flight trajectories to determine the closest point of approach.

IMPACT IN
18
MINUTES

Figure 1: Area Control Operations Room at Swanwick Centre. (Source: NATS)

The London Area Control Centre at Swanwick manages en-route traffic in the London FIR over England and Wales, and the airspace is divided into five local area groups (LAGs): North, South, Central, East and West. These LAGs are subdivided into sectors, and every sector is managed by an executive and a planner controller. Each controller is assigned to a workstation with iFACTS and radar displays installed.

Studying normal work

Traditionally, unsafe situations have been attributed to the unreliable human performance of individuals, instead of focusing on how systems fail. From operational experience and scientific research, we know that decision makers are constrained by limited information, limited capacity of the human mind and limited time.

Consequently, practitioners must face frequent trade-offs in their daily work when dealing with competing goals like safety versus efficiency. In this respect, Shorrock et al (2014) reflect on the importance of the 'local rationality' or local perspectives of the people who actually do the work, and their ability to vary their performance. It is precisely the ability of people to adjust their performance to contextual conditions that explains why systems actually work. Thus, recognising how practitioners face everyday adaptations is a way to understand how expertise is developed. The foundation of 'Safety-II' is that practitioners are a resource necessary for system flexibility and resilience, and that they continuously create safety. In NATS, there is an ethos that 'people create safety'.

Air traffic controllers accept the need for automation so long as new tools are considered to be useful and reliable. By expanding the role of the automation, controllers must build new expertise and adapt their performance to the context and conditions. What actually happens under those conditions is defined as 'work-as-done' (WAD). This can be different from 'work-as-imagined' (WAI), which is the basis of how the work is designed to be done, and trained to be done.

> It is precisely the ability of people to adjust their performance to contextual conditions that explains why systems actually work.

Research approach and methodology

I wanted to explore whether controllers varied their WAD using iFACTS and, if so, to understand why, through considerations of everyday experience, individual and group differences, personal strategies and human factors implications. After an early familiarisation stage studying all available documentation, I completed the data collection process over 21 consecutive calendar days, on daily periods of eight hours, interacting with controllers from all watches. As I hold a valid ATCO licence myself, this helped me to recruit participants, establish rapport with them and understand the context of their work. I conducted 14 direct observations at the Ops Room and 26 semi-structured interviews with en route air traffic controllers working with iFACTS.

Controllers were divided in three groups according to the LAG they work: West, South, and a Dual Validation (South-West or South-Central). After the primary data-collection phase, I transcribed the interviews and analysed textual data to explore relationships and trends, to explain meaning and compare the perspectives of different participants. An interim template was developed based on the data, which was revised until the final template was obtained.

Findings and discussion

Performance variability

By introducing iFACTS, controllers have evolved their controlling techniques according to their working environment. South controllers used more radar-based techniques and used the iFACTS tools differently from West and dual-validation controllers. According to the participants, this is due to the different characteristics of the South LAG sectors, which are generally smaller and require more interaction with traffic than West and Central LAGs. Controllers with a dual validation (including South), use the tools differently than controllers valid only in South sectors, suggesting variety via adaptation.

Acceptance, trust and patterns of use

In addition to sector characteristics, a strong connection was found between controllers' acceptance of automation and their use of iFACTS. Higher trust levels in iFACTS, and the perceived benefits from using it, seemed to affect the controllers' dependence on it. West and dual-validation controllers interact more fluently with iFACTS than South controllers partially because they trust the automation more. This is also influenced by diverse factors such as: the controllers' understanding of the system; the perceived understandability of the technology; perceived technical competence; design; degree of familiarity; understanding of limitations; and the controller's attitude towards it.

When the system is perceived as reliable and accurate, controllers are more eager to trust the tools. Similarly, when they feel they understand the system, they are more eager to trust it, even if it is not completely reliable (see Hilburn, 2003). Participants also claimed that they trust the system as long as the human is responsible for the ultimate decision (see also Bekier, Molesworth and Williamson, 2012). Past experiences, comments from colleagues and direct observations at the simulator, even before the system was implemented, were reported to influence the controllers' experience as users of iFACTS. Controllers' expectations about iFACTS were revised after their first personal experiences and continuous interaction with the system, forming an overall subjective impression towards the technology.

Training and experience

Training and the controllers' early interactions with iFACTS were also found to influence how they subsequently used the system. With the implementation of iFACTS, controllers needed to develop a new set of critical competencies to successfully perform their jobs. This was achieved not only by adapting past experiences and expectations but also by adjusting their own skills through training. The training for iFACTS recognised that the tools would provide

different levels of benefit in different types of sectors. The training was delivered based on functions and was not prescriptive. It allowed controllers to understand the functions of the system and to adapt their use of these functions as appropriate to the sectors. Consequently, controllers have adapted and diversified their usage of iFACTS.

Trainee characteristics together with training design and work environment are considered to be crucial for the learning, retention, generalisation and maintenance of skills. Some controllers concluded that the transfer of training was facilitated because they were motivated to learn during the training process and because they perceived the training as useful. In these cases, they reported the transfer of knowledge to be related to observing others interacting with iFACTS, and to extensive and intentional practice.

Teamwork and culture

The influence of controllers' attitudes on the use of automation is more relevant when analysing this phenomenon from a cultural perspective. In the case of air traffic control centres such as Swanwick, controllers are assigned to different watches, functioning as a community with a lot of shared values and working strategies. To be

> Controllers have adapted and diversified their usage of iFACTS.

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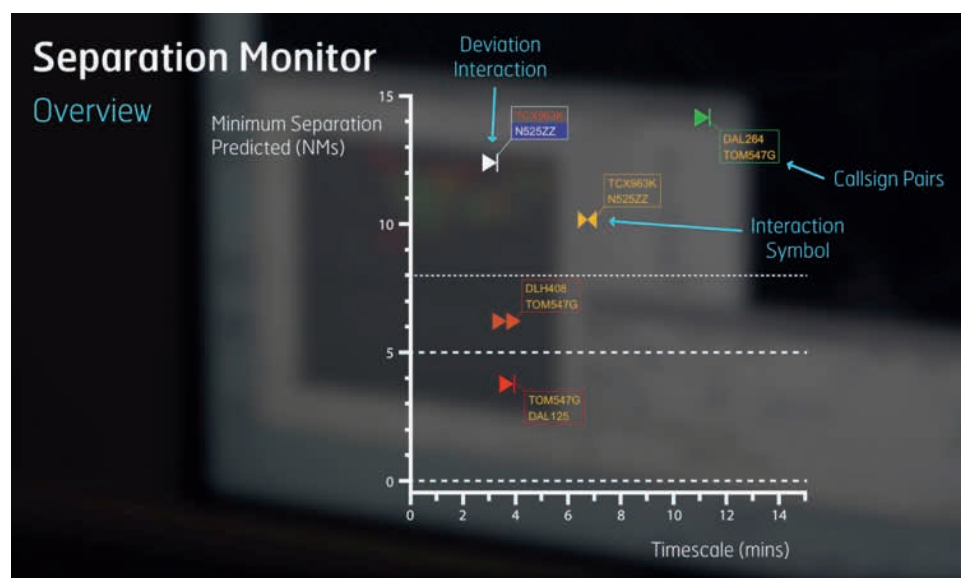
Figure 2: Separation Monitor overview. (Source: NATS)

accepted as a member of the team, "each controller must not only conform with its ways of behaviour, but also adopt its attitudes" (Hopkin, 1995, p.345). Traditionally, informal accepted leaders tend to guide less experienced controllers in both professional and social issues, and their opinion is highly respected among the group. Thus, the ascendency of peers in relation to acceptance and use of iFACTS becomes a relevant factor. Peers that understand and use the system will convey that view to their colleagues either formally (under training) or informally (daily work at the sector). In this context, the role of instructors is essential, because they can impact not only how controllers understand and interact with the system but also their opinion and predisposition about it.

Conclusion

iFACTS entails an innovative operational ATM concept in advanced automation and decision-making support for air traffic controllers. Technology has changed the nature of the controllers' job in a number of ways, and they adjust and adapt their work-as-done when using technology.

This study found that there are variations in how technology is used in practice, for a variety of reasons including acceptance, trust, patterns of use, training, experience, teamwork and culture.

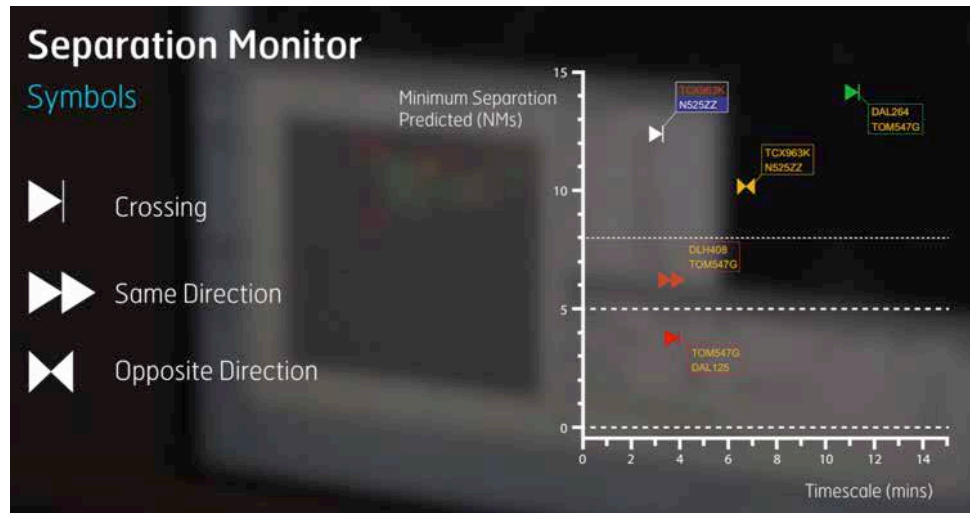It is never just about the technology. It is about the people. ⑤

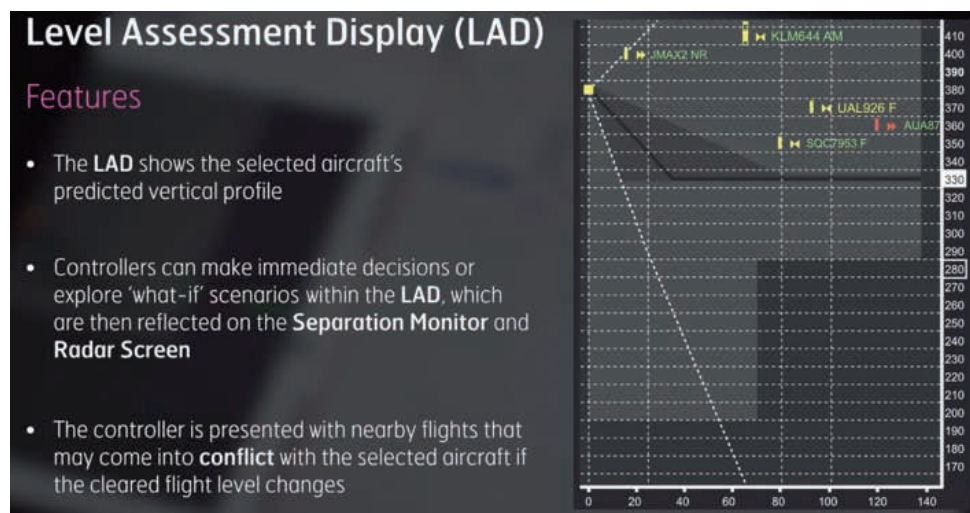Figure 3: Separation Monitor symbols. (Source: NATS)

Figure 4: The Level Assessment Display (LAD). (Source: NATS)

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ROUTINE MAINTENANCE AND ROUTINE OPERATIONS: IT TAKES TWO TO TANGO

Front-line operators such as controllers and supervisors also have an imagination of the work of others, including the work of technicians. But technical systems are increasingly complex, and technicians have less time to understand and maintain them. As **Maria Kovacova** explains, communication, coordination and checklists can help to ensure that things go right.

KEY LEARNING POINTS

1. **Routine maintenance doesn't always go as imagined. Technical specialists work under pressure**

2. **Timely coordination, clear communication and checklists between technical experts and supervisors can help to ensure that things go right.**

3. **When things do go wrong, just culture should apply to technicians as well as controllers.**

Routine maintenance is not what it used to be. Gone are the days when technical experts could run maintenance during night shifts with almost no traffic. Also, technical systems and solutions used by air navigation service providers are now much more complex. Systems are hard to understand even for technical experts.

So imagine now that you are an ATC supervisor. And imagine that your technical colleague comes to you and asks for permission to maintain certain equipment. They say that they will not touch the main system and ATCOs will not even realise that the required equipment is under maintenance. Would you, as a supervisor, trust your engineering colleague?

Why not, when they promise 'no impact' on current performance of technical systems…? Why not, when they are very well trained and skilled specialists on that technical system…? Why not, when they say that the main system has independent set A and set B and in case of failure ATCOs have a backup system almost equivalent to the main system, and this backup system has internally independent set A and set B…?

And what makes you think thos console wasn't wired properly?

Statistically, a total loss of service, like radar or voice communication, is extremely unlikely.

You are not a specialist in this area at all. Your tasks are completely different, such as: opening and closing of sectors based on traffic demand, weather, number of ATCOs available, MIL activities; coordination of all necessary activities with adjacent units; solving unexpected and emergency situations, and so on. So you think…maintenance is under control and the technical experts reassure you about fall-back modes and contingency procedures.

> Even in routine maintenance, things don't always go as imagined

But even in routine maintenance, things don't always go as imagined. Here are some real-life examples that are not so old.

One day, between 0900–1000 two sectors were opened to provide services during low traffic density, with a prediction of high density traffic, which was usually expected during lunch time. During the annual maintenance of the telephone communication system, an external company performed regular testing of telephones under the supervision of an internal ANSP technical expert. At the end of the maintenance, the external company tried to re-arrange cables in an organised way and started to strip some cables at the back of the console of the ATCO working position to help provide easy access to the relevant equipment for the future. During this cable management work, the external technician accidentally unplugged the situation display of one ATCO, who lost the entire display. The ATCO immediately announced this system failure to the supervisor and started to provide services on the backup system, which was fully independent from the main ATM system. At that time, the technical coordination cell was not able to define the cause(s) of failure because the display of the ATM system itself was, at that time, not under monitoring supervision of the technical coordination centre. After 10 minutes, technical experts finally understood the failure and plugged the ATM system display back into the electricity network, and declared that the ATM system was operational without any restrictions.

Another situation occurred during a summer period, one hour before lunch, which meant high traffic load for controllers. Five sectors were opened and the supervisor received a phone call from the technical coordination cell with notification that technical experts will do regular routine maintenance of the radar message conversion and distribution unit (RMCDU A), while RMCDU B will be still operational. This meant that the RMCDE (radar message conversion and distribution equipment) would be running without any change to the ATCO position. RMCDE contains RMCDU A and RMCDU B, while radar information from different radar sensors is brought into RMCDU A or RMCDU B via an automatic line switch (ALS). During this maintenance, a technician switched the ALS from routing data into RMCDU A to RMCDU B. The RMCDU A was ready for maintenance and could be safely switched off. But the technician accidentally switched off the RMCDU B, which was at that time in use for real operation. Suddenly, the ATCOs started to see stars instead of aircraft plots and immediately announced this technical failure to the supervisor. Due to the very quick reaction and notification to the technical coordination cell, technicians switched ALS back to RMCDU A. So the ATCOs had 'only' three minutes of technical failure of the ATM system.

We may wish to have equipment with almost no maintenance during the whole lifecycle, but there is a need for regular maintenance to assure the availability of the technical service. To wait for a period of time with low traffic density is very demanding. Technical experts sometimes have a feeling that ATCOs are not so busy and maintenance could be done as needed, but the view of the supervisor can be completely different: one moment it can be quiet but in next 10 minutes heavy traffic is predicted or weather is going to change radically. Can the technical expert ensure that everything will go right?

In real life there are thousands of scenarios such as those above, but technical failures are not widely known between ANSPs. Increasingly, it is very important to understand the position of each player: supervisor, controller and technician. This means trying to put yourself into the shoes of your colleagues, and ensuring proper and timely communication. Effective communication between technical experts and supervisors is needed in order to be prepared for an operational worst case scenario. Usually in routine maintenance, everything goes right, but we must be sensitive to the possibility of failure (Hollnagel et al, 2013). One good practice is to use checklists on both sides. This helps to ensure a common language and understanding.

Now there is increasing pressure on technical experts to run maintenance faster and more efficiently, and they are forced to improvise in real operation with various pieces of equipment of various ages. As 'frontline' actors under time pressure, they are forced into a situation where errors are more likely. When mistakes do happen, how should we judge technical experts? Remember that just culture principles apply to technicians as well. ⑤

Maria Kovacova is an aviation safety enthusiast actively contributing to safety areas such as just culture, safety management gap analysis and proposals for safety improvements, introducing practical and efficient safety methods and tools to air traffic control. After her graduation in aviation engineering, she continued her mission to improve safety processes in air navigation services, supporting just culture within the Slovak Republic and providing training for different aviation stakeholders.

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'SAFETY HOLMES': A DRAMATISED INVESTIGATION TO BRING SAFETY TO LIFE

How effective is the learning from safety occurrence reports? Most of us have probably experienced 'report fatigue' and there are limits to learning from safety reports. We need more interactive methods to help our learning. HungaroControl have a dramatic solution, where imaginary safety occurrences are acted out by employees. As Sherlock himself said: "There is nothing like first-hand evidence". **István Hegedus** outlines the initiative.

Like most ANSPs, Hungarocontrol has numerous methods of safety communication and learning, such as reports, presentations, articles, surveys and e-learning courses. Most of these appeal to one's logic and rational thinking. While these are essential aspects of how we learn about safety, they tend to suffer from two problems. First reports, presentations and so on are usually not interactive. Second, such methods tend to take a linear approach to communicating a narrative. Third, they do not tend to appeal to emotion.

HungaroControl organised its first Safety Day in 2012 with the purpose of facilitating safety awareness across the organisation in a new way. The idea is to help colleagues experience the significance of safety through various participative activities, such as taking part in a Safety Holmes session.

István Hegedus works as an ATM Safety Promotion Specialist at HungaroControl. Previously he was in charge of e-learning system implementation, e-learning course delivery and training development, and also has extensive experience in teaching aviation English to a variety of audiences.

KEY LEARNING POINTS

1. **The Safety Holmes dramatisation complements safety reports and safety training with participative, emotional and first-hand experience.**

2. **Safety Holmes can be used to help colleagues reflect on work-as-done and work-as-imagined for themselves, and the influences and interactions that bring about events.**

3. **Dramatisation engages the imagination of all participants to help make safety learning to stick.**

Safety Holmes is a dramatised, interactive presentation of ATM safety issues on the annual, in-company Safety Day organised by HungaroControl. It is a mock investigation into an imaginary ATS occurrence, where the roles are played by employees. The purpose of a Safety Holmes session is to help people discover for themselves the subtle yet important safety issues and interconnections that exist in a complex organisation, and which all contribute to the safety level achieved by an ANSP.

Safety Holmes takes the form of an ATS occurrence investigation where staff prepared for the roles (the 'actors') play the parts of employees involved directly or indirectly in an ATS occurrence. They present their story to other employees attending the event, who act as an investigatory body, or to several groups of 4-6 investigators. The investigators' task is to reveal the underlying factors that contributed to the occurrence and then recommend changes and improvements in the functioning of the organisation (the ANSP).

In preparation for this, the 'investigators' (the audience) get a short verbal summary of the occurrence, then they listen to the story of each member of staff (the actors) involved in the case, and interview them. The actors come to the stage one-by-one, and stay on the stage when their part is over, so in the end all six or seven actors sit on the stage, and the investigators are free to ask questions to anyone of them. This interview part is followed by a 15-20 minute analysis and recommendations session, when the investigators work in their group to identify the causes and factors, and to draw up their conclusions and recommendations. Finally, they are asked to briefly present these to everybody in the room.

The members of staff participating become emotionally involved in the

process: the 'actors' present their stories as if it happened to them personally, and the 'investigators' have a feeling that they are interviewing people who were actually involved in an occurrence. This emotional factor is there to make the revealed issues be remembered for longer and hopefully to influence real life action at work 'when nobody is watching' more effectively than a scientific, rational presentation of the same issues.

Of course, the issues that the organiser wants to raise are carefully hidden in the Safety Holmes story, but typically the investigators come up also with extra ideas. The issues can be virtually anything with relevance to the performance of the people, procedures, equipment and the organisation as a whole. We have highlighted many issues using the Safety Holmes method, including:

- ATCO fatigue
- staffing
- TRM (EC-PC communication)
- communication between operational and support ("office") units
- clarity of procedures (e.g. reporting procedure)
- compliance with procedures
- adequacy of risk assessment
- planning
- understanding of how OPS works
- communication between ATCO and ATSEP
- prioritisation of resources (procurement), and
- consideration of human factors.

So far we have had positive reaction from participants. Safety Holmes is often mentioned in the feedback as the highlight of the Safety Day. The next HungaroControl Safety Day, including the fifth round of Safety Holmes is scheduled for 3 May 2017. Of course, a Safety Holmes session can also be used to highlight differences between work-as-done and work-as-imagined. For example, certain procedures or safety nets intended to increase safety could look good on paper, but in real life they may

overload or frustrate the user. The result can even be counterproductive to safety: imagine STARs that are too difficult for pilots to fly or for ATCOs to manage due to the lack of proper validation in a simulator, or drawn up without adequate ATCO and pilot involvement. This could lead to a less safe practice: more shortcuts or visual approaches, eventually increasing the number of go-arounds or the risk of runway excursions at an airport. Or imagine an STCA warning, where of course the visibility of the warning is vital, but may actually hinder the controller in reacting properly, because the visualisation of the STCA renders certain radar label information invisible.

Based on feedback from HungaroControl participants, the Safety Holmes dramatisation method helps to complement safety reports and other aspects of safety training, adding an emotional, first-hand and fun dimension. In doing so, it engages the imagination of all participants to help to make safety learning to stick longer. ⤴

Tips for running a Safety Holmes:

- Always use invented cases that can never be identified as one particular case, especially not as one that happened at your ANSP. This is to avoid the feeling of being pointed at or blamed.

- If possible, enroll 'actors' with some actual experience of the role played: e.g., an ex-ATCO will surely deliver a convincing performance in the role of an ATCO.

- Keep the Safety Holmes session to about 90-100 minutes maximum.

- A good number of "investigators" is 15-30, working in 3 to 5 groups.

THE HIDDEN OBVIOUS

Observation is an important method to understand work-as-done (WAD), and various observational safety methods are in use in aviation and other industries. These provide data that can help to illuminate work-as-imagined (WAI). But for those observing work-as-done, familiarity can breed assumptions, and what you find may be what you look for. As **Paula Santos and João Esteves** explain, 'stupid questions' are needed to close the WAI-WAD gap.

One basic method to capture work-as-done is to observe it and then to discuss it with those who have been observed. So in October 2015, NAV Portugal launched a project to start observational safety surveys in the control tower responsible for the provision of air traffic services in Faro International Airport.

The main objective was to capture real-time information related with the normal operation, to reduce the gap between work-as-done and work-as-imagined or described. In other words, to better understand work-as-done at the front line.

The approach was based on the Day 2 Day observation method developed by NATS, with the addition of a debriefing session after each observation. The focus of observations was on actions or aspects of work that positively contribute to safety. Several observation areas were agreed with multiple associated observation parameters. For example, in the observation area "Runway entrance and exit – timing of departure and arrival clearances" there were four observation parameters, one of them being the time of delivery of landing clearances.

KEY LEARNING POINTS

1. Observational checklists that prescribe what to look for give you numbers but can hinder observations. Keep your eyes and mind open.

2. Assumptions hide the obvious. What is obvious for a controller needs to be made explicit to be understood by non-controllers.

3. Questions and discussions are needed to understand the how and why of performance.

DOES HE NEED HELP?

Observational and data analysis protocols were developed and implemented for the project. The Portuguese ATCOs professional association was consulted and involved in the process from the very beginning. ATCOs from the concerned unit, all of them current and former OJTI's were selected and trained as Observers. This allowed a reduction of the required training time.

The planning foresaw six observational periods along the year of 2016, each one with two days duration, each with a total of six observations (three per day), resulting in 36 observations during 2016. An observation was planned for a minimum of 30 minutes and a maximum of 45 minutes, though in practice took up to one hour.

Checklists covered several observational areas and observational parameters previously defined by the observation team (see Figure 1). These parameters were basically a list of good practices that were expected to be observed during normal operation. These were

Figure 1: Example observational checklist

observed and a frequency analysis was done on the application of these practices. The frequency of application of the practice was recorded, from 'always' to 'never' or 'not applicable' for each observation area and parameter. Also recorded were the traffic volume (low, medium or high) and complexity (routine, occasionally difficult or hard). Additionally, trade-offs and compromises, as well as drift and adaptation in work-as-done were recorded during the observations, and analysed in the debriefing sessions that took place immediately after.

The safety department was available for background support during each observational period, but never involved in the observations.

Each observational period resulted in a report, incorporating the observations and interpretations of the observers. This report was made available to all staff members of the ATC unit, to operational management, to safety management and to people trying to document work-as-done.

Besides the conclusions on the degree of adherence to good practices and the identification of certain operational constraints, the analysis provided important information on work-as-done.

The most relevant information was not the numbers but the additional records. Here is an example: there was a case reporting that "that the ATCO has actively cooperated with the APP position colleague, both informing
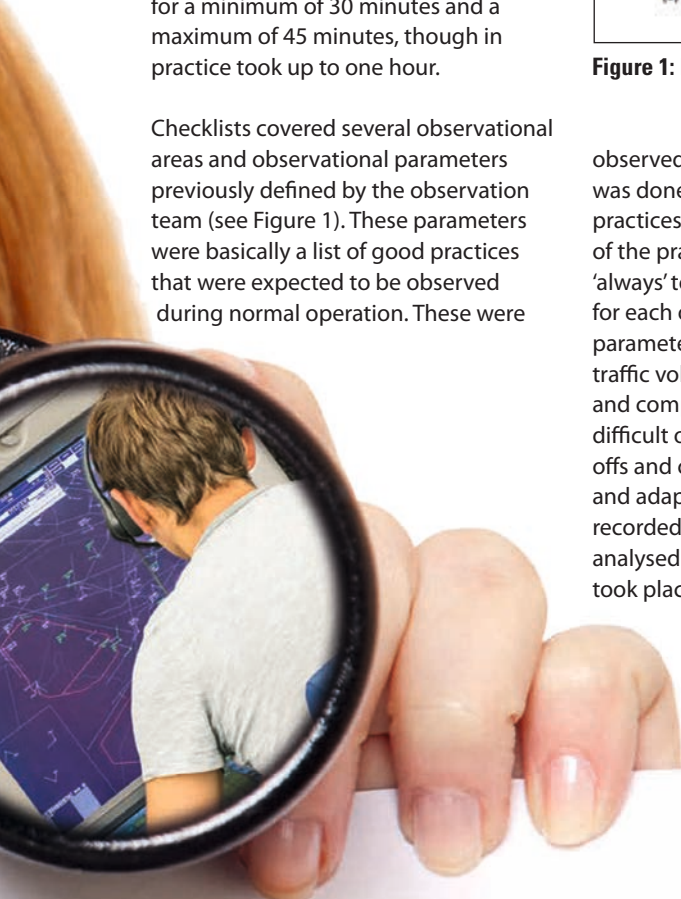
about the inexistence of departures, to ease the sequencing of departures, and handling the APP incoming calls when the colleague was busy." What can one ask about this report? It depends on what one is trying to find.

Here are some 'stupid questions' that were asked:

- What was the trigger for this ATCO to identify that his colleague needed help?
- How did he detect this need to help?
- Can it be described?
- Are there identifiable criteria?

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Through all of the observation reports the common pattern was attention to the surrounding environment and to the evolution of traffic, proactive actions to ease the workflow, and requests for help.

Through all of the observation reports the common pattern was attention to the surrounding environment and to the evolution of traffic, proactive actions to ease the workflow, and requests for help. In essence, this is what is required for a team to function, but it is not written in work descriptions. If it is not known to and understood by others beyond the ops room, then how can it be supported?

Some areas needed clarification in the reports. Some things were not captured in the observations because they were 'obvious' to the operational observers and thus not recorded. For instance, how did the ATCO in the example above detect that his colleague was busy? Well, he was not answering his calls as fast as he usually did. This is obvious to those who do the work(-as-done), but perhaps not to those further removed from the front-line.

It was verified that the ATCOs in that ATC unit are well aware of good practices and apply them systematically in their day-to-day operations. From the operational perspective, however, the results achieved were lower than expected, due to the fact that no major 'discoveries' were made regarding potential improvements in the operational routines and procedures.

Still, the observation project has helped to reduce the gap between work-as-done and work-as-imagined/described. There is a clearer perception of the subtle success factors for safety, and a better understanding of the role of resources and constraints in real-time operation.

Yes, teamwork is key for safety. That is obvious to those involved, but hidden from others. ⑤

WORK-AS-IMAGINED AND WORK-AS-DONE:
A SAFETY MANAGEMENT REALITY CHECK FOR REGULATORS

Regulators are in a difficult position. Despite conflicting goals, increasing workload, very limited resources, and distance from the reality of work-as-done, they have to imagine and prescribe – at some level – how work must be done. For regulated service providers, compliance is not straightforward. In this article, **Don Arendt** explores some of the tensions of regulation.

KEY LEARNING POINTS

1. As risk is inherent in aviation operations, safety performance can be expressed in terms of how well risk is managed.

2. Regulators and service providers must understand and carefully consider the situations faced in real operations (work-as-done) to accurately design the controls necessary for safety (work-as-imagined).

3. Regulatory and oversight strategies must also be matched to the service providers' safety management capabilities to foster growth in their safety cultures.

4. Service providers and regulators must both be able to look not only 'if' compliance is achieved but 'how' regulations are implemented in order for them to serve as effective risk controls.
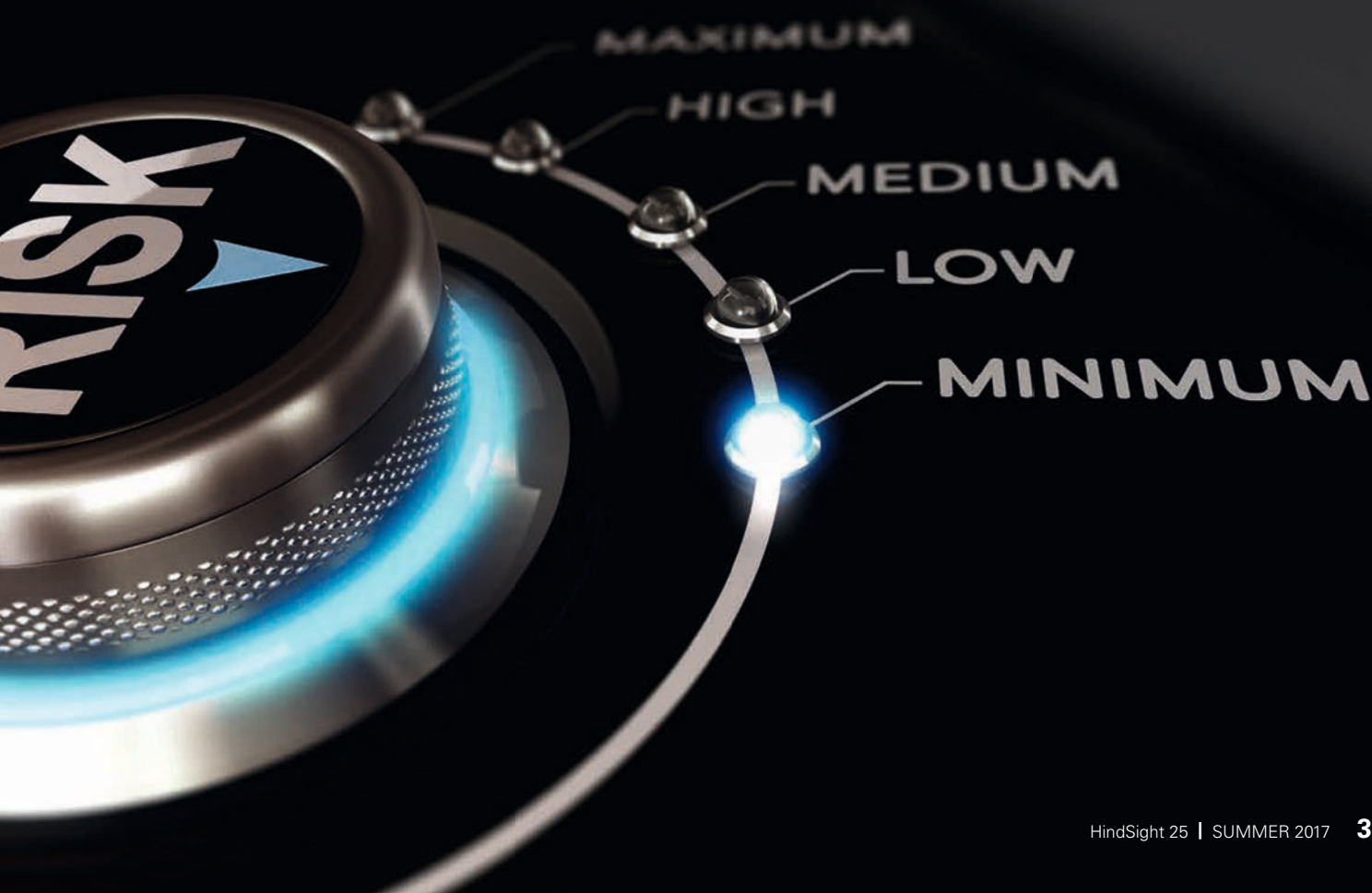
Sensemaking in a changing world

The U.S. Supreme Court once stated, "Safe is not the equivalent of risk free". This is certainly true in aviation where risk is inherent and safety performance can be expressed in terms of how well risk is managed. In studies of 'high reliability organisations' (HROs), which consistently operate safely in high-risk environments, Professors Karl Weick and Kathleen Sutcliffe offer 'sensitivity to operations' as a key trait of these organisations. The ability to perceive situational realities – 'work-as-done' – and adapt to them is essential for consistent risk management.

People make sense of situations based on their perception of the current situation and their anticipation of its future state. The accuracy of perceptions with respect to actual situations is important in decision-making. What makes sense to people involved in actual work situations may not match how the situation was envisioned by designers of processes, procedures, and rules. When this happens, people may be forced to work in ways that don't make sense in terms of the current reality of their work. People may be unaware of the risks that exist and risk controls that apply to their actual situation. Decision-makers, who are not aware of how work is done at the sharp end, may base their decisions on assumptions rather than reality.

Imagining the work-as-done: Rulemaking challenges

Rulemakers must assume a set of system and environmental conditions, hazards encountered, risks to be controlled, and constraints that can be applied to control those risks. Compliance consists of applying rules to the assumed situations. Thus it is vitally important for regulators to fully understand the real situations faced by service providers ('work-as-done') in order to accurately 'imagine' the controls necessary for safety.

At the same time, regulators have to understand the need to be flexible in discerning the range of capabilities of typical service providers and the level of maturity of individual service providers to determine the best regulatory and

- **These new routes aren't what I imagined!**
- **Me neither!**
- **Nor me!**
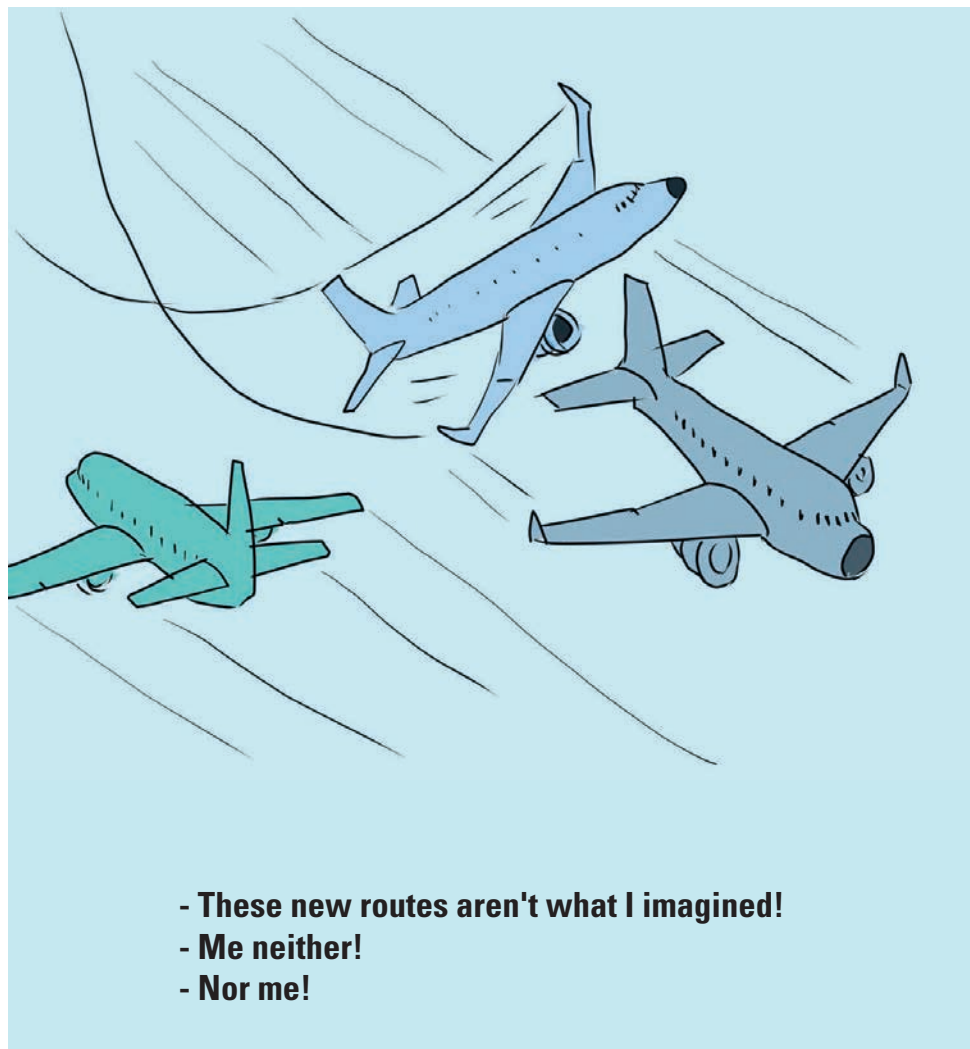
oversight approaches. Applying an approach that is too prescriptive may stifle innovation in mature, capable organisations while others may need considerably more structure. Regulations and oversight must provide a uniform level of safety performance across the aviation system under varying individual service provider needs and capabilities. Regulators must have a clear understanding of how work is actually done and how their actions will apply across a broad range or service provider capabilities.

Doing the work: effective compliance

Service providers must determine how their systems and environmental conditions compare to the assumptions of the regulations in order to comply effectively. Mismatches between what was imagined by regulators vs how their regulations are applied by service providers can render regulations ineffective as risk controls. It will be important for regulators to provide service providers with information regarding the assumptions of the rule in terms of expected behaviours and the operational situations envisioned.

This information will be essential for effective compliance with the regulations.

This suggests a more nuanced look at what regulators mean by 'compliance'. Compliance is often viewed as being black and white while it is seldom, if ever, so simple. Even the most prescriptive standards require understanding and development of strategies to fit behaviours into the expectations of the rule. Regulators must determine if compliance, in the context of work-as-done, accomplishes the intent of the rule as an effective control of an imagined risk situation. The focus needs to be on effective compliance: not just if service providers comply, but how.

Oversight of work-as-done

The regulator's culture can have an impact on the maturation of service providers' safety management capability and the growth of their cultures as well. Regulators must recognise the safety management capability of service providers they oversee. This is part of regulators' recognition of work-as-done, i.e., what's

really going on out there. Oversight strategies that over-emphasise a prescriptive approach may inhibit service provider cultural growth, although they may be appropriate in some situations, particularly with service providers' whose safety culture is still maturing.

Regulators must also take the time to collect information and analyse the results of their oversight activities, not only to determine the level of compliance with regulations but also their effectiveness. This may entail a recalibration of the assumptions that went into the design assumptions of the regulations and the oversight approach.

Oversight strategies that over-emphasise a prescriptive approach may inhibit service provider cultural growth

Regulators must understand not only what can go wrong, sometimes referred to as Safety-I, but they must also have a clear recognition of desirable performance, associated with Safety-II. Safety-I tends to be measured by the numbers, rates, causal factors, etc. of safety failures. Having a clearer picture of work-as-done may help us to recalibrate what we as assume is 'right', in ways that better fit actual situations.

Challenges for performance based oversight: Imagining reality

The move toward performance-based oversight will also require regulators to be more attentive to the status and changes in conditions in service providers' systems and operational environments, and to their safety management capability. We can't assume that all service providers will have the same levels of skill in developing effective performance based compliance strategies. Thus oversight strategies must be able to discern whether the service provider's methods of compliance are achieving the expected results of regulations in terms of effective risk control. Oversight strategies must include continuous performance assessment and adaptability of practices to control risk in situations that may be very dynamic.

Fostering cultural growth

Regulators also need to consider whether our approach to service provider/regulator relationships can enhance or hinder growth in the maturity of service providers' safety culture. As an organisation's safety culture and their approach to safety management matures, they become less dependent on external inputs and gain a higher degree of collective awareness of risk. Less mature organisations may respond to prescriptive standards and directive oversight, but may be less capable of proactive risk management. More mature organisations may develop and apply innovative strategies to proactively identify and address new hazards and foster a collective mindfulness, the 'sensitivity to operations' – work-as-done, within their organisations. This may be more effective than a 'one size fits all' prescriptive strategy. Regulators' safety promotion needs to include educational efforts to foster growth of effective safety management capabilities of service providers and a flexible oversight approach rather than a 'one size fits all' strategy.

Safety Management International Collaboration Group (SMICG)

The SMICG, a group of representatives of aviation safety authorities from 20 States/ international organisations, was established for the purpose of promoting a common understanding of safety management, including safety management system and state safety program principles and requirements among regulators. The SMICG is completing a development project to provide tools and processes for assessment of service provider safety culture and recently commenced work on a similar process to assess regulator cultures and the effects of both on safety performance. To help States

evolve towards performance based oversight the SMICG also developed an SMS evaluation tool and published guidance and a training outline for inspectors. The SMICG intends to more fully explore the needs of performance based oversight in the near future.

Conclusion

Regulators must make certain assumptions about both broad sectors of the industry and individual service providers: work-as-imagined. In order to make appropriate decisions, regulators must have an accurate assessment of the situations faced by service providers: work-as-done. As performance-based oversight strategies are increasingly applied, it is essential that both service providers and regulators share information in order to assure the accuracy of their collective knowledge of work-as-done. Oversight approaches that do not match the actual situations of those populations (the reality of their work-as-done) may be ineffective as risk controls. ⟲

Visit the SMICG page on Skybrary: http://bit.ly/SMICG

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WORK-AS-IMAGINED, WORK-AS-DONE, AND THE RULE OF LAW
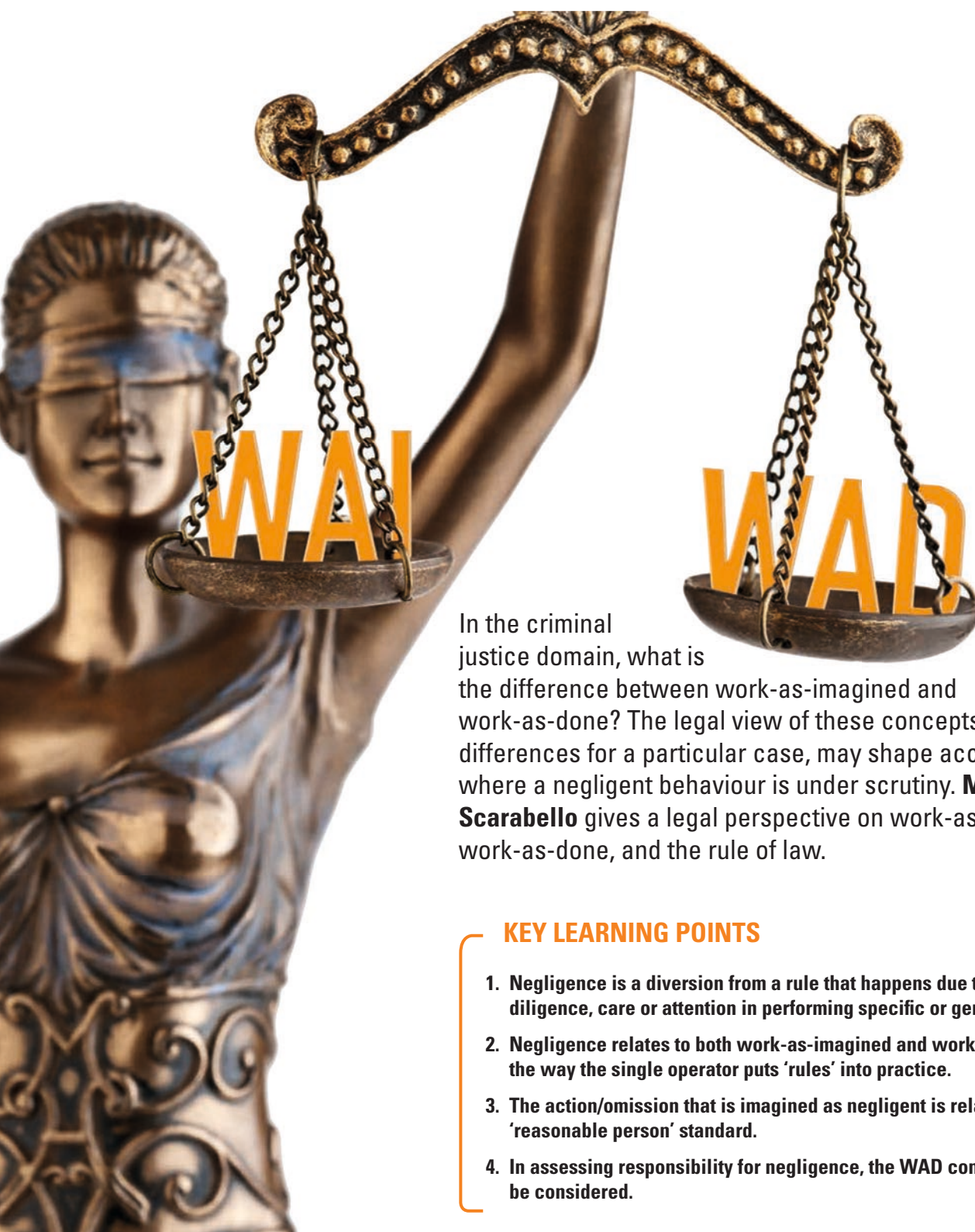
In the criminal justice domain, what is the difference between work-as-imagined and work-as-done? The legal view of these concepts, and any differences for a particular case, may shape accountability where a negligent behaviour is under scrutiny. **Massimo Scarabello** gives a legal perspective on work-as-imagined, work-as-done, and the rule of law.

KEY LEARNING POINTS

1. **Negligence is a diversion from a rule that happens due to lack of diligence, care or attention in performing specific or generic tasks.**

2. **Negligence relates to both work-as-imagined and work-as-done: the way the single operator puts 'rules' into practice.**

3. **The action/omission that is imagined as negligent is related to the 'reasonable person' standard.**

4. **In assessing responsibility for negligence, the WAD context should be considered.**

01 The criminal justice system is intended to find out if there is someone to blame for an unwanted outcome that is relevant to criminal law, and to punish the individual of the actions/omissions that led to that event.

Over-simplifying, the first thing that has to be assessed in cases involving negligence is if the event is a consequence of the action or omission of someone involved in the 'process' within which the outcome occurred. There are scientific-naturalistic rules to follow in this seeking.

After that, assuming that a positive answer is given to the first search, the attitude and mind-set of the person under scrutiny must be investigated, in order to find a 'negligent behaviour'.

Negligence, roughly speaking, is an unwanted diversion from a rule that happens due to lack of diligence, care or attention in performing specific or generic tasks. The person has to have a 'legal' duty to perform a task in a specific manner, in order to accomplish a certain outcome. The term 'legal' is really general, since the sources of these rules can be different.

02 That being said, let's try to verify if work-as-imagined (WAI) and work-as-done (WAD) theory somehow fits in this process. At first glance, the legal duty that has been violated belongs to WAI world. 'Legal' means, for the purpose of the law, written, or procedural, and applicable to number of cases, so that similar cases are treated in the same way and different situations differently. Why should WAD be assessed? The WAI-WAD gradation does not belong to general rules, nor to the way these rules are written in the law, in contracts, in policies, or in procedural documents. It is something that is related to the way the single operator puts these 'rules' into practice, in real cases and environments.

It is a general principle in negligence theory that the action/omission that is imagined as negligent is related to the 'reasonable person' standard. This concept is aimed at personalising the average degree of care and competence to the specific domain within which

the event occurs (healthcare, aviation, driving, etc.). So, there will be a reasonable ATC controller (a reasonable tower, approach, ground controller) a reasonable pilot (a reasonable PIC, first officer, Boeing PIC, Airbus PIC) and so on, depending on the case under investigation.

This reasonable person must be appropriately informed, capable, aware of the law, and fair-minded. Since it is a standard, it can never go down, but it can go up to match the training and abilities of the particular person involved. For example, in testing whether the particular controller misunderstood an aircraft identification so incompetently that it amounts to a crime (because some bad outcome occurred), the standard must be that of the 'reasonable ATC controller'. If that particular controller has extraordinary competence (because he/she is recognised as 'the best' tower or approach controller), a higher degree of diligence and care can be expected.

03 This being the general frame of the reasoning, WAD may find its own space in further personalisation (in the sense stated above) of the context where the event occurred.

WAD is the consequence of many factors that induce the diversion from WAI. Let's look at some examples.

A) An ATC controller in an airport that normally has low to medium traffic.
Traffic increases rapidly due to a new airline that sets its base (for contingent reasons) in that field. The management of the ATC provider decides not to recruit new personnel because the airline is due to move in a short time. Workload for the operators begins to increase, and shortcuts in some procedures are made in order to ensure safe and regular ground and air operations. The situation becomes stagnant and the airline decides not to move. Nevertheless, controllers seem able to carry on their duties, endorsed by the management, by shortcutting here and there, in some non-safety-essential processes, and these procedures become the WAD workflow in that environment.

Now, what if an unwanted event that affects safety occurs? The 'reasonable person', in this case, is one who is comparable to those controllers who work there, based on WAD and not WAI.

B) Cockpit environment.
A newly designed digital management process of some in-flight procedures is provided in the cockpit of a modern jet liner. The system is so complex and interacts with so many other systems that, even though training was given, the crew is not completely aware of the tasks that must be performed in response to some malfunctions. The manual provided does not help in solving that particular situation, which evolves rapidly in an emergency. The crew decides to act in a way that is not imagined in the manual, because they guess the only possible action is to switch the system off. So they perform the task manually, and the emergency is resolved, but nevertheless a minor event occurs.

In assessing responsibility for negligence, the WAD context should be taken into consideration.

04 Given this argument, the WAD context should be considered in answering the fundamental question, could a different action be taken by the particular person under scrutiny?

It is not an easy task, though, to define for each environment or situation a WAD workflow model that can be used as a standard to evaluate negligence.

In some domains, best practices can fill the gap between abstract prescriptions and real-case management, although when the WAI-WAD relation is concerned, the concept itself of 'best', referring to the practice, may not necessarily reflect WAD. ⚓

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Massimo Scarabello has 20 years of experience as a court judge, and is a student pilot and aviation enthusiast.

IMAGINE REALITY

Sometimes, we imagine that we are capable of more than we can really are. When this happens, more often than not, it is the routine rather than the exceptional that fools us. Because something is so routine and ordinary, we tend not to pay much attention to it. But perhaps we should. In this article, **Wolfgang Starke** invites us to 'imagine reality'. How can procedures be better designed for human use?

"A common mistake that people make when trying to design something completely foolproof is to underestimate the ingenuity of complete fools." (Douglas Adams)

I would not say that professionals in aviation could be called "complete fools". Still, some parallels can be observed, not because of foolishness but because we are fooled by routine and occasionally our natural desire to reduce effort.

One of the common mistakes that we make repeatedly is ignoring how we work when faced with routine, boring tasks. One of these examples is the problem that pilots occasionally tend to extend flaps at too high a speed when they are high or fast on approach. A typical idea of fleet chiefs is to introduce a 'speed checked' call-out of the monitoring pilot. With this procedure, it is imagined that the monitoring pilot is first observing the speed, confirming it is below maximum extension speed of the flaps, then saying "speed checked" and moving the flap lever.

What is happening in reality? As the speed is usually below the maximum permissible speed for flap extension, the monitoring pilots simply always responds "speed checked", regardless of the actual speed.

In most of the cases the speed is checked after moving the lever, which routinely leads to some degree of chaos and bustle after recognising the mistake. Still, the imagined protection failed.

We see a difference between the underlying idea of the procedure and the way it is done in reality.

KEY POINTS

1. **We tend to ignore how we work when faced with routine, boring tasks. We also naturally tend to reduce workload wherever possible.**

2. **We sometimes see a difference between the underlying idea of a procedure and the way the work is actually done.**

3. **Procedure designers need to respect human capabilities as well as limitations, and how we think and work in reality.**

4. **When designing procedures, the operational staff should always be consulted.**

Something comparable is the altitude select function of the autopilot installed in the Bombardier Dash8-Q400. The Q400 is one of the very few aircraft that will, flown by the autopilot, not automatically level off at the selected altitude. If you want it to level off, you need to press the ALT SEL switch after selecting the desired altitude.

As this design of the autopilot is rather predestined to produce level busts, a procedure was put in place always to call out the flight level and altitude select armed after selecting a new altitude. The pilot flying should always verify (read!) the selected flight level and the armed altitude select mode from the flight mode annunciation panel (FMA) and then call out "flight level 240, ALT SEL". In theory, this would eliminate all the possible level busts as there is no way altitude select can not be armed when it is read aloud from the FMA by the pilot flying, and confirmed silently by the monitoring pilot.

Again, if we look at work-as-done we see some degree of difference. Of course, some will always perform this procedure as it was designed. But the majority of pilots tend to occasionally call out something they could never have read because either the correct altitude or the indication of altitude select armed was never displayed. Pilots tend to do this because in many, many cases it is displayed and therefore they do the callout as they always do it.

Part of the problem in the two cases is a lack of understanding of the human brain. The brain tends to reduce effort as much as possible. This is why we still can read words even if half of the characters are missing or if the middle characters are scrambled. Our brain recognises the word without reading all the characters. In the two cases above, this means that the brain is not really looking at the FMA as it is always displayed there. However, if we do not turn in the correct altitude, mistune it or forget the altitude select mode, our brain will forget to recognise this for the very same reasons.

Another reason for not complying with procedures is when procedures are designed in a way that cannot be complied with in most cases. My company for instance has designed a decelerated approach that requires pilots to fly 140 knots at four miles from threshold. This

approach technique was designed to reduce unstabilised approaches and reduce the likelihood of missed approaches following these unstabilised approaches.

This was a worthy goal that was never met. Usually this technique is not used. But why? The simple answer is that every air traffic controller on a busy airport will request that aircraft keep 160 knots to four miles final. This is not a problem in itself, but it requires pilots to deviate from standard operating procedures during every second approach. That in turn lowers the threshold for SOP-deviation significantly, even if that is not instructed by the controller.

Another problem is habituation. Usually there is distance measuring equipment (DME) at every major airport. As this is a fact, pilots tend to use the DME-distance as distance to the airport, which works out well in most cases.

Flying into a smaller airport recently, my first officer duteously tried to fly the prescribed decelerated approach. Unluckily, the DME was not located at the airport but rather about two miles behind the landing runway, which made its reading distance to threshold plus three miles. He was then instructed to keep 150 knots to four miles. He ended up totally astonished, two miles on final, gear up, without landing flaps and 150 knots on the airspeed indicator. The mandatory missed approach followed.

He simply made the mistake doing what he always did on all the other approaches, using the DME as distance to the runway. But in a world that requires less and less thinking while we are supposed to stick to our procedures as close as possible, we are still not released from thinking.

Designing procedures: Some advice

All of this shows two basic requirements for designing procedures.

First, designers of procedures need to consider the peculiarities of how we think and work. Simply adding a callout usually works in the short term at best but never in mid- to long-term. It should further be understood that the human

brain will, to a certain degree, reward the operator for non-compliance if the non-compliant way is easier and usually leads to a comparable and safe outcome. If that is the case, operators will – sooner or later – take the easier way, perhaps disobeying the procedures.

This is a common reason why the overwhelming majority of unstable approaches are completed to landing instead of ending up in a mandatory missed approach at the stabilisation height. Completing the landing is simpler and usually leads to a safe outcome.

Second, while designing procedures the operational staff should always be consulted. There is no sense in procedures that seem perfect in theory but will not and cannot be adhered to in reality.

When the Russian engineers for spacecraft did not know how to proceed because a problem seemed to be without solution, they occasionally described the problem to young pupils and then listened carefully.

Of course, we do not fly to the moon but maybe it is wise to ask people that do not sit in offices all day thinking about theory. Maybe asking pilots, controllers or all the other operational staff will sometimes highlight issues that do not exist in theory but can cause problems in reality. This is why ICAO described committees like the Runway Safety Teams, where all the operational parties can give their opinion and search for possible mitigations to safety issues.

As a conclusion, we have to say that our procedures eventually need to respect the capabilities as well as the limitations of a human brain. Furthermore, these procedures need to be compatible with what we can expect in reality – our day-to-day business.

If procedures are not designed according to these two basic requirements, as simple as they might seem, these procedures will never work as they are imagined.

"In theory, there is no difference between theory and reality."
(Unknown)

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FATIGUE MANAGEMENT:
PROCEDURE VS PRACTICE

Fatigue management is an issue that is growing in importance with the demands and pressures of 24-hour operations and with ever-greater cost-efficiency. In this article, **Nick Carpenter and Ann Bicknell** discuss purposeful and tactical non-compliance with procedures for fatigue management. What lies in the gap between procedure and practice?

KEY POINTS

1. Procedures have an important place in safety-critical enterprises.

2. Humans are adaptable problem solvers trying to do their best.

3. For fatigue management, blind compliance with procedures to result in safe operations may not always ensure safe operations.

A growing challenge

On 12 February 2009, a Colgan Air Dash-8-400 crashed whilst on approach to Buffalo-Niagara Airport New York in the United States of America. Forty-five passengers, the four crew and one person on the ground died in the accident. Inappropriate inputs by both crewmembers contributed to exacerbate the stalled condition of flight 3407. The National Transportation Safety Board cited pilot fatigue as a contributing factor. The United States Federal Aviation Administration (FAA) listed 'Reducing Fatigue-Related Accidents' on its 2016 most wanted list.

The fatigue problem is linked to the economics of aviation. In the United States, deregulation of the airline industry occurred in 1978, with open skies between the EU and US arriving in 2008, eliminating service restrictions between the two trading blocks. The result is that airlines operate in an increasingly competitive environment, fuelled by the rise of Low Fare Airlines. The fall-out has included seven bankrupt airlines in Ireland, 39 in the UK and over 100 in the United States since 2000; a rate of just under one per month.

The pressure means that crews are working longer. In the first large-scale survey by the London School of Economics of pilots' perceptions of safety within the European aviation industry, 51 per cent of pilots surveyed felt that fatigue was not taken seriously by their airline, and 28 per cent of pilots felt that they had insufficient numbers of staff to carry out their work safely. The issue is reflected in the British Airline Pilots' Association campaign to raise awareness of fatigue within the industry. Concurrently, regulatory authorities are relaxing prescriptive flight time and duty limitations designed to keep pilots alert, exemplified by the FAA's new rules that exempt freighter pilots.

To try to understand this problem further, I recruited 11 medium-haul pilots to participate in semi-structured interviews and the transcribed data was thematically analysed. The pilots, all employed by a foreign carrier, conduct 'tours of duty' where they spend approximately 20 days working day and night flights (irregularly allocated), followed by a return to their country of domicile and 10 days off. As an experienced airline pilot, I was afforded candid disclosure of the current 'coping strategies' of this hard-to-reach professional sample.

I wanted to investigate how pilots attempt to cope with fatigue. It was anticipated that they would employ strategic and tactical methods.

Strategic planning typically involves lifestyle adjustments prior to duties starting. Tactical coping involves behaviours used to maintain alertness whilst on trips.

In general, pilots:

- found sleep less restorative in company-provided hotels
- struggled with changes from day to night duties
- found multiple sector duties more demanding, and
- felt that diverting was the most fatiguing operation.

Many participants instinctively used tactical techniques identified by sleep laboratories; coffee, cockpit lighting and conversation being the most popular tactical methods to maintain alertness. Some used cognitive methods including games, reading and music and a minority used physical methods such as exercise, both in the aeroplane and between flights.

Don't worry Jim, have a look at the roster!
Soon you'll become an experienced pilot, like the rest us!

Enabling non-compliance: When procedures and practice diverge

Bearing in mind aviation's heavy reliance on, and belief in, procedures, the most interesting outcome was the discovery that many of those interviewed have operated contrary to company procedures in a limited number of areas. Hollnagel et al (2014) suggested that what workers actually do at work can sometimes be very different from what managers, and those who write procedures, believe that they do. This difference between 'work-as-imagined' and 'work-as-done' only becomes apparent after something has gone wrong.

Typically, the procedure that fails has been used for a significant amount of time before being implicated in an incident. In the current context, crews are expected to remain alert in the cockpit without the use of controlled rest and are not allowed to use medication to help them to sleep between duties. Of those interviewed, almost all coordinated with their flight deck colleague to enable them to sleep in the cockpit whilst on duty. Some of them resorted to medication to enable recuperative rest between duties in contravention of current procedures. It is only through

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Nick Carpenter is a military trained and commercially experienced airline pilot flying wide body aeroplanes in Asia. His interest in flight safety has inspired him to study for both a Bachelor's and a Master's degree in Psychology and he is currently in the process of establishing a peer support network for contract pilots in Japan. The research cited formed the Dissertation for Nick's MSc.

non-compliance with procedures that interviewees felt they were able to maintain their alertness at critical stages of flight: approach and landing.

What's prescribed is not necessarily what happens

For these pilots, blind compliance with procedures is not always the ideal method of delivering safe flight. This is something that we need to explore, whilst considering how to integrate 'enabling non-compliance' into safe operations as one method of optimising performance. That said, judging when it is prudent to contravene established procedures is difficult. Indeed, many would argue that this is a radical concept, but procedures have to evolve with the context in which they are used.

'Enabling non-compliance' has a dual purpose: facilitating open disclosure about frontline procedures while enabling procedure writers to adjust their work-as-imagined to the changing needs of frontline employees. This research suggested that those interviewed believe that they are capable of judging when non-compliance is prudent. The focus, then, needs to be on building flexibility into Standard Operating Procedures to close the gap behind work-as-imagined and work-as-done, whilst training crews to give them greater cognitive skills and judgmental awareness to step outside the rules when they have reached the limit of their effectiveness. Research by Robert Mauro (2016) and

by Frederik Mohrmann et al (2015) suggests that resilience training should include training in decision-making and information analysis, including the use of virtual experience, strategies for decision shifts and the appropriate allocation of time to endow both competence and confidence in a non-jeopardy environment where flexibility and decision shifts are accepted.

Implicit in this change to training is the need for cultural change within organisations where simulators are used for competency training instead of only checks, and where an acceptance that stepping outside of procedures can, on occasion, be acceptable.

Of course, questions remain about risk and safety monitoring, procedure design and just culture. If work-as-done is sometimes deliberately contrary to procedures: 1. How can the company understand what is going on, and ensure that risk is adequately assessed in light with regulations and its safety management system? 2. How can procedures be adapted to be more flexible to allow for discretion around practices that aviation professionals deem to be safe and effective? 3. How will companies and national judiciaries treat pilots who purposefully contravene procedures, even when it makes sense to them to do so, if an accident occurs? These are questions that the industry will need to consider as work becomes more complex and demanding than we can imagine. ⅃

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EXPERTISE
AND COMPLIANCE

Work is increasingly prescribed in regulations, policy, procedures, and technology. The idea is that compliance equals safety. But over-compliance has emerged as problem, with implications for system resilience and just culture. Can we find the right balance between expertise and compliance? **Antonio Chialastri** explores the issues.

KEY POINTS

1. **Pervasive control over pilots' decisions risks turning pilots into simple executors or system operators, with implications for decision making and just culture.**

2. **Pilots use their expertise and experience to create safe boundaries around their decision making, sometimes despite pressure to the contrary.**

3. **Over-compliance is an increasing risk to system resilience, and perhaps a symptom of a lack of trust.**

Thirty years ago I was a young pilot who started with a lot of passion, a strong determination and great expectations. Obviously, I lacked expertise. An airline took me as a novice pilot, trained me extensively, checked me thoroughly and after many years and much flight time, it appointed me as a Captain. This was the normal career of a pilot: novice, expert, Captain. After that, the company implicitly was telling me: "Now, you're the Captain. I trust you. Act on my behalf".

From Master after God to system operator

"Master after God" was a phrase used during the XVII century to define the Captain. The meaning behind this phrase didn't come from an idea of divinity of the Captaincy. The reason was that the Captain had no one above him, except God. The ship-owner had no ways to communicate his intentions to the Captain apart from sailing to far destinations; the delegation was absolute. The Captain knew how to act in the interest of the ship-owner.

Expertise is hard to define. Knowledge interacts with expertise in a subtle way. Sometimes we don't know that we know. 'Gut feeling' arises from past experiences; a kind of lesson learnt without awareness. However, expertise is essential in the decision-making process. It helps to anticipate events and allows the pilot mentally to be five minutes ahead of the airplane, deviating from procedures if it is necessary.

With the evolution of automation, the enhancement of meteorological predictions and the continuous updating of flight data, pilots are often seen as simple executors or system operators.

What I see today is a pervasive control over pilots' decisions – an over-emphasis on compliance with the standard operating procedures, the reduction of Captain's autonomy, with implications for decision making and just culture. There are several examples of the erosion of the Captain's authority, including fuel policy and the compliance monitoring programme.

Fuel policy

The fuel carried on-board depends on many variables. First of all, the fuel uplift is a kind of bet: pilots determine in advance how much fuel is required for their trip. They decide the correct quantity of fuel getting weather forecasts but, as Mark Twain has said: "Never make predictions, especially about the future".

Today, the actual fuel reserves available on a plane are really lean. Here we need to uplift extra fuel to cope with foreseeable changes in the flight time or with contingencies that may arise once airborne. How much fuel is needed is not a clear cut decision-making process. It comes from experience, from knowledge and from all the available technical, operational and weather data. You know how much fuel is (really) needed only once you have landed… safely.

It is the eternal 'production versus protection' conflict. The pilot's job as imagined is full of flights carrying minimum fuel. The pilot's job as really done is made of Captains uplifting extra fuel; a decision made based on their

**Report to Operations: All OK...
Engine vibrations have ceased...**
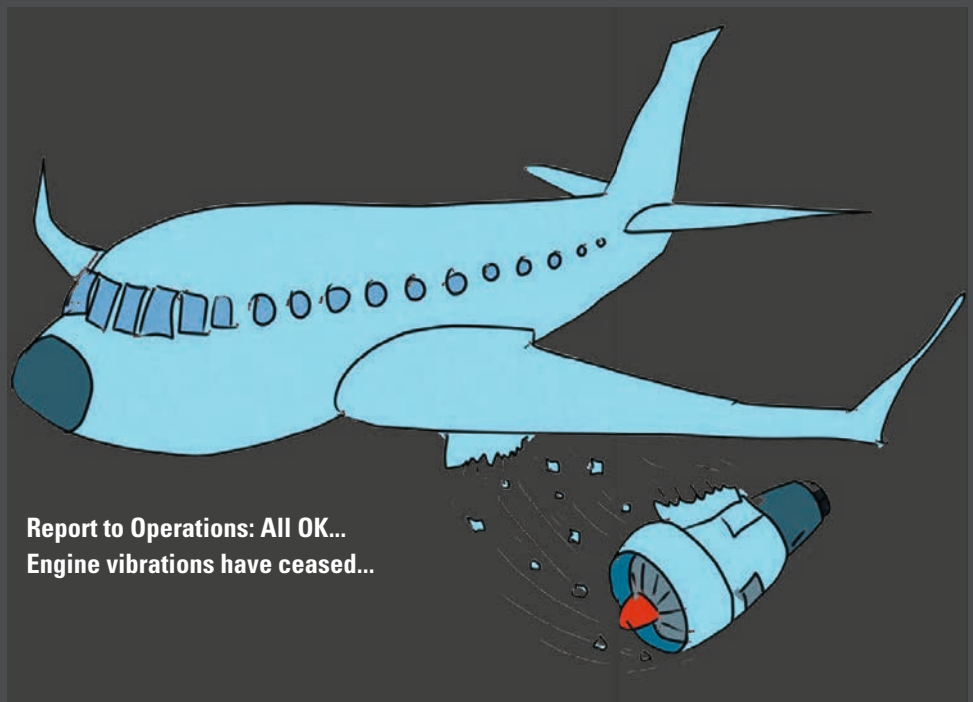
experiences. To fill the gap between work-as-imagined and work-as-done, crews are put under pressure, asking them to justify why they don't fly with the minimum fuel. Companies' policies are enforced with no written recommendations but with the pervasive pressure of the organisational climate. The pilots who comply with these policies go ahead in their careers. The others, who object that this is a dangerous practice, are openly or tacitly kept at bay, realising sooner or later that they came to a stop in their career progression.

Compliance monitoring

Another form of company pressure comes from compliance monitoring. A network of data recorded in real time keeps the company's eye watching carefully from behind the crews' shoulders.

In the last twenty years, thanks to the introduction of newly conceived aircraft (fly-by-wire, dark panel, automation, etc.) pilots are somehow 'constrained' to respect procedures and standards if they want to interact with their airplane. The 'rogue pilot' described by Major Tony Kern some decades ago – a reckless guy that disregards flight discipline – is hardly observable today.

Psychological assessment during the selection process, standardised training, social control, automation and even traffic congestion, leave few chances to deviate or to personalise flight management.

Moreover, the coexistence of many nationalities in a single airline requires strict control of standard operating procedures. A common language is a good means to obtain safety.

But pilots cannot do everything by the book. A margin of discretion is useful to fill the gap between work-as-imagined and work-as-done. Flexibility during operations in a real scenario is one of the main sources of resilience. You can't ask someone to ride the wave on a surfboard while standing rigid. Flight, as well, requires an intelligent use of knowledge, experience and trust.

Updating one's own course of action is a sign of good airmanship.

Take the example of stabilised approach, one of the most effective tools to avoid undesired outcomes. An experienced pilot should know when to abort the landing, focusing on the real conditions and not only on numbers. Most of the time, if an approach is not stabilised, it's a wise decision to go around. But it's even wiser to leave the final decision to the Captain, whether it is better to perform a landing or abandon the approach. When the autonomy of a well-trained, expert and reliable crew is limited by fixed numbers and inhibited by the fear of reprimands, the system's resilience is inevitably affected.

Do you trust me?

After thirty years since my beginnings as a pilot, I've noticed that the training pendulum is swinging back. The normal curriculum that started with the novice, proceeding to the expert and eventually to Captain is running backwards. Expert professionals are hired by the airlines, but are told: "I don't trust you, so you must fly as a novice".

This approach is not for free, and accidents can happen because of over-compliance, associated with fear of blame, disciplinary actions or even loss of job.

In this context, the 'big brother syndrome' makes decision-making puzzling. This is the feeling of being remotely controlled by someone, ready to punish or to demote from Captaincy. In doubt, should we act in order to obtain the safest and best result, or simply apply rules regardless of the outcome?

The B-777 accident in Dubai occurred at a big airline with strict emphasis on standard operating procedures compliance. Reading the brief description of the accident, the touchdown was achieved at around 1000 metres down the runway. There was enough runway ahead to stop with adequate safety margins. He opted to go around, a decision that (along with

a skill-based error) led to a stall and eventually a crash. Sure, with hindsight everybody is able to determine which is the safest course of action.

I tried to imagine how he felt during the split-second decision that led to a go-around. This made me think that perhaps something resounded in the Captain's head: "What if I don't go around?" "Are they going to call me soon after we have completed the parking check list?" "How can I justify a landing, notwithstanding an aural warning: Long flare?".

Maybe, the Chief Pilot, using sound judgement, would have understood the Captain's decision to land, disregarding the aural warning. Might the emphasis on compliance be eroding the pilot's self-confidence? Is compliance monitoring becoming a kind of sword of Damocles? There are many cases of football players that, feeling the distrust of their team manager, perform badly. The same applies for most of us, pilots included.

Pilots, and especially Captains, cannot be half-heartedly trusted.

Train them, coach them, trust them. Everyone will benefit. **S**

Antonio Chialastri is an A320 Captain and writer.

GUIDING THE PRACTICE: THE 4PS

Work-as-imagined is prescribed in a number of written forms, from the specific to the general. They all influence work-as-done in some way, but how can they best support and guide practice? In this article, **Immanuel Barshi, Asaf Degani, Robert Mauro, and Loukia Loukopoulou** outline a simple framework that anyone can remember and explain to others: The 4Ps.

KEY LEARNING POINTS

1. While Procedures and Policies are prevalent in aviation for routine and exceptional tasks, it is neither possible nor desirable for Procedures and Policies to contain all of Practice.

2. The nature of operations means that Practice must be guided by the overall Philosophy of the organisation.

3. The Philosophy statement sets a clear order of priorities that must apply under all conditions. It also guides the creation of consistent Policies, which in turn guide the creation of consistent Procedures.

4. The Philosophy recognises the limits of the imagination and provides guidance for operational decision making when the Practice must fall outside of existing Procedures and Policies.
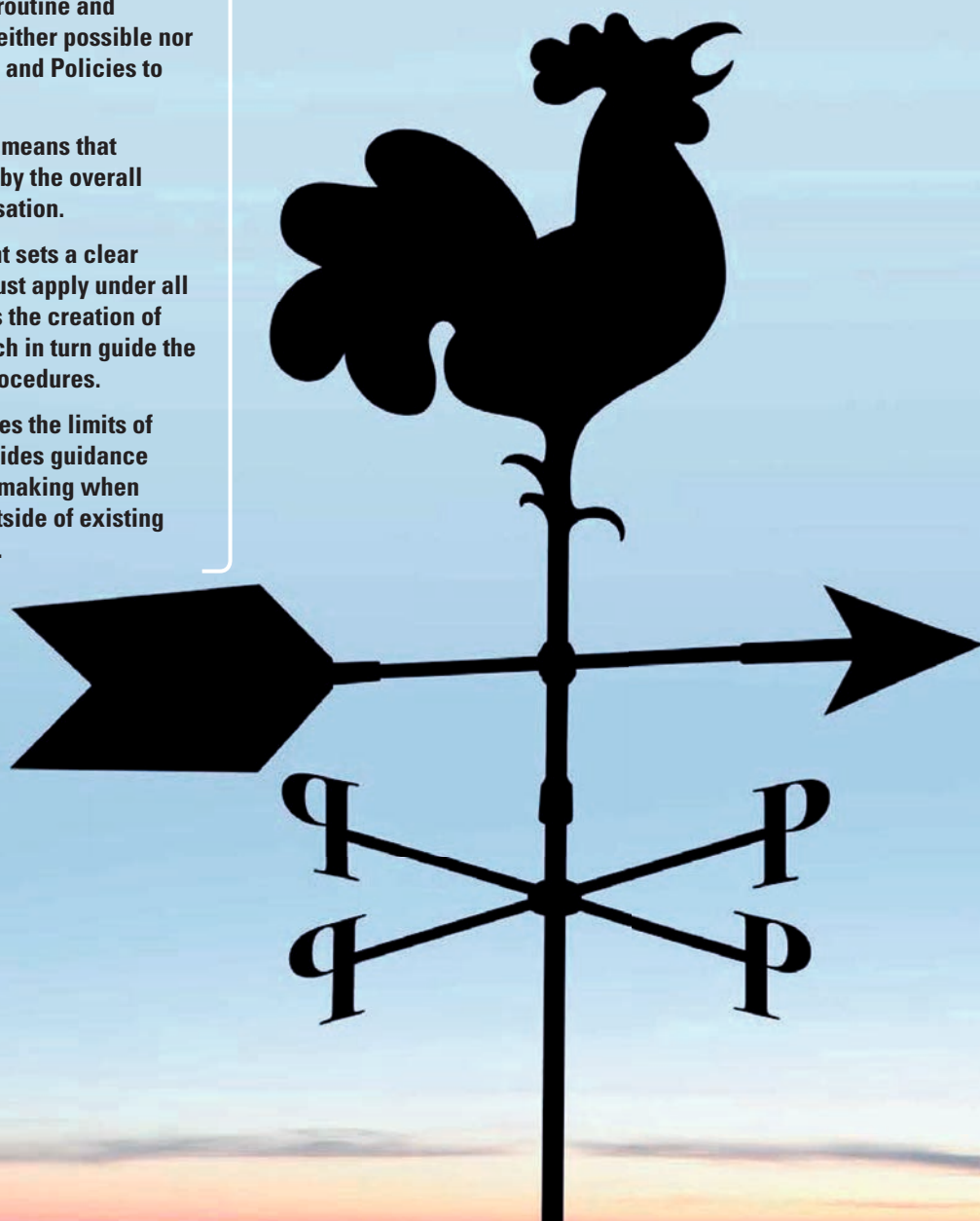
Air traffic controllers and pilots appear to live by procedures and policies. There are procedures for how to set up the workstation or cockpit, how to start the engines, and how to vector aircraft. There are policies that may govern how you speak and how you dress and even how to leave your station to use the restroom. Policies and procedures can be very useful. They can organise work, increase effectiveness, efficiency, and safety and even make work more enjoyable (Barshi, Mauro, Degani, & Loukopoulou, 2016). But poorly designed or disorganised policies and procedures can make work dispiriting, difficult, and dangerous. Creating an effective set of procedures requires coordination of the 4Ps: Philosophy, Policy, Procedures, and Practice.

Practice is what happens on the front line. It is the sum total of all the decisions operators make and all the actions they take during operations. For pilots, Practice is what gets recorded in FOQA/FDM (Flight Operations Quality Assurance/Flight Data Monitoring, the aircraft data bus) and ASAP (Aviation Safety Action Program/Partnership, the airline's confidential reporting system) data, and what gets observed during line checks and LOSA (Line Operations Safety Audit). For ATC/ANSP, it is what you see in the tower cab, on the floor in the radar facility; it's what gets recorded in the radar tracks and what's reported in confidential reports. It is work-as-done. It is the reality of the operation.

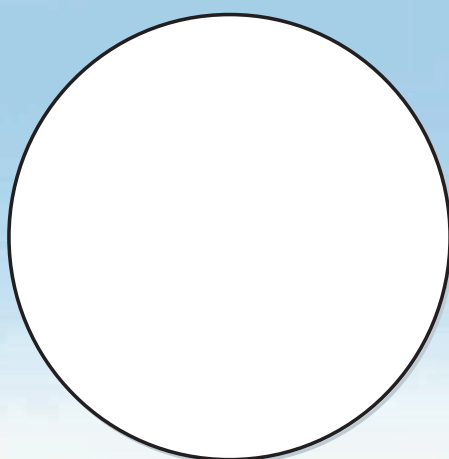We can visualise the Practice as the sum total of activities as in Figure 1. It is often believed that all practices should follow prescribed company Procedures (SOPs). It can be visualised with a circle of Procedures that encompasses all of Practice, as in Figure 2.
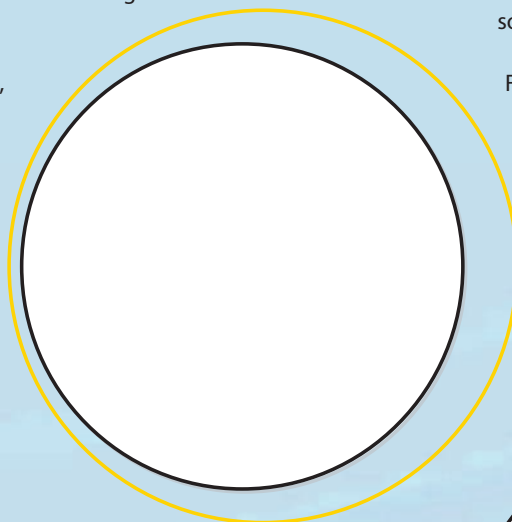

Figure 2: Procedures (yellow circle) contain the whole of Practice.

In reality, Procedures can only cover some of the Practice.

As much as some managers and lawyers would like it, it is not possible for Procedures to contain all of Practice. Nor is it wise to try. It is impossible to anticipate or imagine every situation such that a procedure could be written for it. Procedures assume a specific set of fixed conditions, but daily operations are conducted in a dynamic environment. The choice of actions in some situations must be left to situation-specific judgement. Furthermore, some activities for which procedures could be developed are better left to personal choice or a recommended practice. Over-proceduralising can lead to resentment and to resignation such that when a situation arises for which there is no procedure, people refuse to decide and to act on their own. Over-proceduralisation can also lead to conflicts among procedural requirements and it becomes impossible to operate without violating some procedures. It may also become impossible to actually know and remember all the procedures that are in books and manuals.

In reality, Procedures can only cover some of the Practice (see Figure 3).

Furthermore, Procedures do not cover a continuous, coherent area of the Practice, but only some areas of the Practice, and these areas may be disconnected. There isn't just one big procedure, but many separate different procedures. This can be visualised in Figure 4.
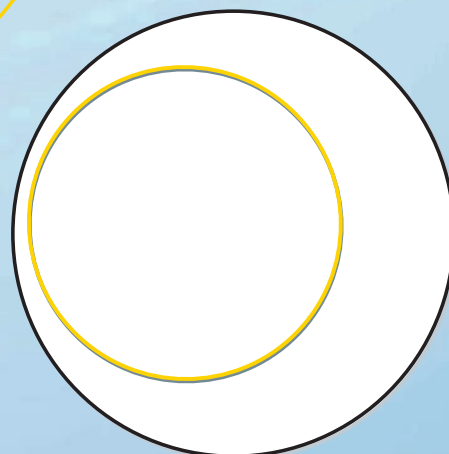

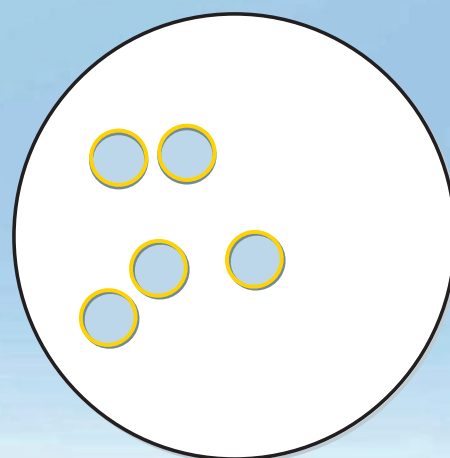**Figure 3: Some of Practice is covered by Procedures (yellow circle).**

Figure 4: Some Practices are covered by separate and different Procedures (small yellow circles).

Figure 1: The Practice

Having many separate and different procedures creates two problems: 1) how to ensure consistency across procedures, and 2) how to guide operators in situations when there is no procedure.

To create consistency across procedures and to guide the Practice that falls outside of Procedures, organisations create Policies. While Procedures address specific situations and dictate specific actions, Policies cover a broad range of situations, and provide guidance for decision making and action in those cases in which Practice must fall outside of existing Procedures. For pilots, Policies are also set to guide and limit general behaviours (e.g., a uniform policy), the way procedures should be conducted (e.g., checklists will be called for by the Captain on the ground, and by the Pilot Flying in the air), or the general ways in which equipment should be used (e.g., automation policy).

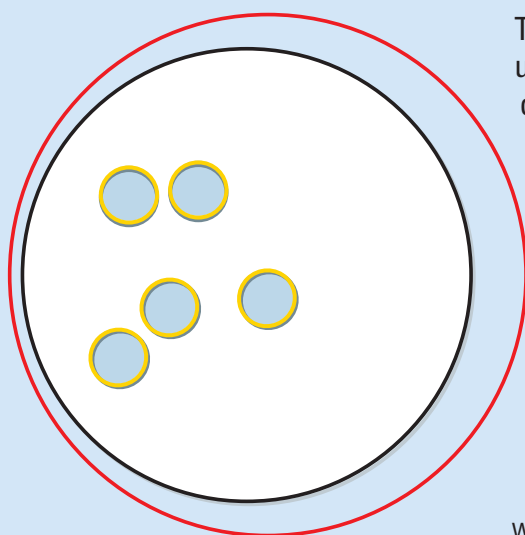Some would like to visualise Policy as encompassing all of Practice as in Figure 5.

Figure 5: Practice as contained by Policy (red circle).

That too is impossible. There isn't just one over-arching Policy, but several different policies. And again, Policies are fixed and the operation is dynamic, and takes place in an ever-changing environment. Like Procedures, Policies are work-as-imagined. In truth, Policies cover some groups of procedures and some parts of Practice, as can be seen in Figure 6.
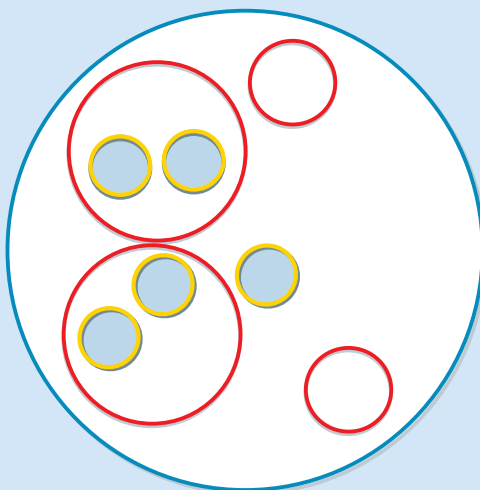
Figure 6: Policies (small red circles) apply to some Procedures and to some areas of the Practice.

The dynamic, and at times unpredictable, nature of operations may lead operators to find themselves in situations for which no specific Procedure exists and for which no broad Policy applies. In such situations, the Practice must be guided by the overall Philosophy of the organisation.

Within their range, Policies guide the development of Procedures, and they guide the Practice when there are no procedures. But just like procedures, Policies are limited too. They cover separate areas and are different. So we are faced again with the problems of 1) how to make policies consistent, and 2) how to guide the Practice that falls outside of policies. The

dynamic, and at times unpredictable, nature of operations may lead operators to find themselves in situations for which no specific Procedure exists and for which no broad Policy applies. In such situations, the Practice must be guided by the overall Philosophy of the organisation. A coherent and comprehensive Philosophy also guides the creation of consistent Policies, which in turn guide the creation of consistent Procedures.

An operational Philosophy is a statement of values. It explicitly articulates the operator's core beliefs. It reduces inconsistency among Policies and provides guidance in situations for which there is no Policy. Furthermore, because at times values might be in conflict (such as safety and on-time performance), the Philosophy statement sets a clear order of priorities that must apply under all conditions (e.g., it's always more important to be safe than to be on time). The Philosophy applies universally; a Policy applies to a particular set of conditions.

Ideally, Practice, Procedure, and Policy are contained within the organisation's Philosophy as can be seen in Figure 7.

Figure 7: The Philosophy (green circle) contains all of Practice.
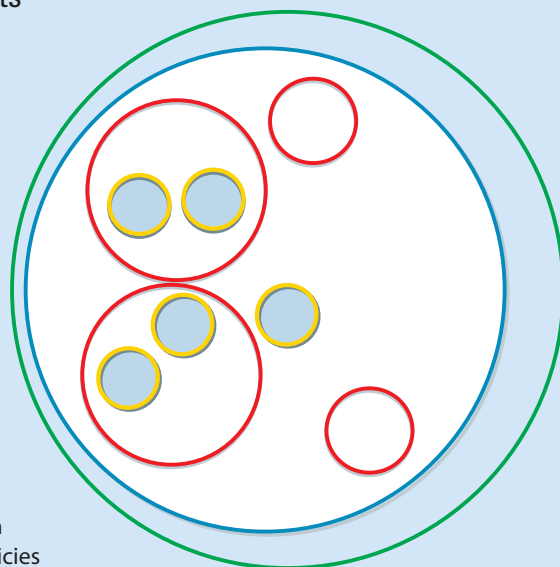
The Practice is work-as-done. Procedures and Policies describe the work-as-imagined. The Philosophy recognises the limits of the imagination and provides guidance for operational decision making when the Practice must fall outside of existing Procedures and Policies. When practices exist outside of any procedure, policy, or philosophy, they are unguided and are a potential source of error and inefficiency. Besides guiding the Practice, the Philosophy also provides the guidance to align the Policies and Procedures into a single consistent and coherent framework (Degani & Wiener, 1994). This Philosophy, Policy, Procedures, and Practice framework is called: 'The 4Ps'. The 4Ps framework provides a systematic way of thinking about the relations between practice, procedures, policies, and philosophy.

Specific procedures are required in situations for which there is only one acceptable way to perform. These are situations in which the risk of variability in performance is too large for the operator to accept. For instance, during an ILS approach, the aircraft must be on the glide slope beam and on the localiser beam. It is not acceptable to be anywhere else. Thus, the cockpit approach procedure specifies that any substantial deviation must trigger a go-around. At the same time, the flight crew is given some discretionary space with respect to the landing configuration. It is allowable to land with different flap settings, depending on a number of variables, and it is possible to extend the landing gear at different points in time. The discretionary space is bounded such that the aircraft must be properly configured by a specific point in the approach. If the aircraft is not properly configured by that point, a go-around must be initiated per procedure. The discretionary space is also bounded by Policy and Philosophy such that the crew may not configure the aircraft very far in advance of the landing and thus waste time and precious fuel. But when a flight crew is uncomfortable with landing on a wet runway in a heavy crosswind, even though it's within the limits of the policy, and a go-

around means late arrival, increased fuel consumption, and other costs, the policy is irrelevant because the operational philosophy clearly places safety above efficiency and on time performance.

A clearly articulated Philosophy provides guidance for the development of consistent Policies, which in turn provide guidance for the development of consistent Procedures. Procedures dictate the

Practice in those situations for which there is only one acceptable way to perform. Policies guide the Practice in those situations that fall outside of Procedures, and the Philosophy guides the Practice in those situations that fall outside of Policy. When the Philosophy, the Policies, and the Procedures are clear, coherent, consistent, and comprehensive, the Practice, the work-as-done is well-guided. 5

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Dr. Robert Mauro is a Senior Research Scientist at Decision Research and an Associate Professor of Psychology at the University of Oregon. He works on automation, pilot and space flight controller training, flightdeck procedures, pilot decision-making, and risk assessment. He has worked with regulators and major airlines in the USA and Europe, and his work has been supported, among others, by NASA, the FAA, and the National Science Foundation.

Dr. Loukia Loukopoulou is an aviation Human Factors professional with the Flight Safety department at SWISS International Air Lines. She is responsible for implementing and running the airline's Fatigue Risk Management program, while also involved in a number of projects concerning flight deck procedure and training issues. She has lived and worked in the USA (U.S. Navy, NASA Ames Research Center), and Greece (Air Accident Investigation Board, Hellenic Air Force).

VIEWS FROM ELSEWHERE

In this special section of HindSight, we introduce some **'views from elsewhere'**, from outside of aviation.

This is inspired by our experience of the European Safety Culture Programme, which has surveyed over 30 ANSPs. This has uncovered Operational Safety Needs in the ATM Network, which were outlined in the EUROCONTROL Director Generals speech at the 2015 CEOs' Safety Conference in Split, Croatia. The five needs are as follows:

1. the need for visible operational safety improvements
2. the need to understand everyday work
3. the need for better human-systems integration
4. the need to improve interconnections between departments or divisions within our organisations
5. the need to look outside, beyond our own ANSPs and even beyond our own industry.

Some of these needs have been the subject of this and previous issues of HindSight, and they will help focus future issues. The fifth need, however, is often a blindspot: the need to look outside, beyond our own ANSPs and even beyond our own aviation industry. Going outside of ATM and aviation, we are a member of a small number of safety-critical industries, which face different risks but similar issues. Sometimes we need to look outside of our own industry. **In this issue, we consider healthcare.**

https://www.eurocontrol.int/speeches/operational-safety-needs

"I WOULDN'T HAVE DONE WHAT THEY DID"

When looking from afar at others' performance when things go wrong, it is easy to imagine that we, in the same situation, would have performed better. In this moving article, **Martin Bromiley** – an airline Captain and founder of the Clinical Human Factors Group – recounts the tragedy that befell his late wife and family when Elaine Bromiley died in a routine operation. The lessons are relevant to all front-line professionals.

KEY POINTS

1. **When we think about 'work-as-imagined', we tend to think of others at the blunt end.**

2. **As front-line professionals, we do not simply represent the reality 'work-as-done'. We also imagine what others do and what we would do – and even what we really do now.**

3. **We need challenge our own assumptions about how we would perform in a challenging situation, and take steps to ensure that we are prepared – as best we can be – for a future that might be hard to imagine now.**

I've been lucky to get to know many accident investigators, fortunately not in direct connection with my job! Of all the conversations that I've had with them, one stands out above all others: a UK Air Accident Investigation Branch Investigator who said to me that when something goes wrong, good investigators ask themselves, "Why did it make sense at the time?".

As I survey other safety critical industries I often wonder if the difference between work-as-imagined and work-as-done defines how well those industries perform. Over the history of aviation, there has been a continuous realignment of work-as-imagined and work-as-done, in response to accidents, near misses, and routine work. As well as independent accident investigations and mandatory and voluntary reporting schemes, as explained by Matthew Syed, author of *Black Box Thinking*, many airlines have *"real time monitoring of tens of thousands of parameters, such as altitude deviation and excessive banking, allowing continuous comparison of performance to diagnose patterns of concern… Aviation, then, takes failure seriously. Any data that might demonstrate that procedures are defective, or that the design of the cockpit is inadequate, or that the pilots haven't been trained properly, is carefully extracted. These are used to lock the industry onto a safer path"*. There are always gaps and always will be, but we have measures to reduce the gap and we all need to play our part in doing that. In many ways, this is what aviation safety is all about.

Not all safety critical work in other domains has benefitted from the same attention to safety and human factors.

Sadly, I was to discover that not all safety critical work in other domains has benefitted from the same attention to safety and human factors. In 2005, my wife was admitted to hospital for a routine elective procedure. Elaine was very healthy but she had some problems breathing through her nose when she got a cold or flu, and it had caused a serious infection. So it was recommended that she should have routine surgery on her sinuses to sort the problem out. She was admitted to a clinic on 29 March 2005. After just over 20 minutes, Elaine was brain dead. It would be another 13 days before she really was dead.

Elaine was being cared for by an experienced anaesthetist and his experienced senior assistant. They did a thorough pre-operation assessment and there were no particular causes for concern. Elaine was anaesthetised at 0835 that morning. The plan was to use what is called a laryngeal mask. She was anaesthetised and they went to fit the mask but it wouldn't fit. Her jaw was too tense, which isn't unusual under anaesthesia. She was given some more drugs and different sizes of masks were tried.

But things were going wrong. She had started to turn blue, a sign that she wasn't getting enough oxygen and the indications of her blood oxygen levels were starting to fall.

Four minutes in, her oxygen levels had fallen to 40%. Anything below 90% is considered to be critical. She was technically now hypoxic.

Six minutes in, the anaesthetist and his assistant called for help. They started to attempt to intubate – to put a tube down her airway, which is standard practice in this sort of situation. After a call for help went out, over the next couple of minutes a number of people arrived: the surgeon waiting to perform the operation, another anaesthetist, another assistant, and two recovery nurses. The senior assistant asked her colleague to fetch the tracheostomy set to allow the team to gain surgical access to Elaine's airway if needed. Her colleague came in and announced that it was available, but the doctors seemed to have completely ignored her. They were gathered around Elaine, attempting to intubate using a variety of different techniques and tools. Probably under the stress, they didn't even realise she was there. Another of the nurses came in and saw Elaine's colour, saw her vital signs and knew instinctively that it was very serious.

Ten minutes in, this became a situation – with hindsight – called 'can't intubate can't ventilate', which is a recognised emergency in anaesthesia for which guidelines exist. The guidelines suggest two options, one of which was, at this stage, the only solution available - surgical access. At this point, everything the doctors had tried had failed. Her oxygenation was 40% or lower and had been for over six minutes. She was blue. But the operating theatre was equipped to the best standard. There was nothing missing that would have made a difference. The anaesthetist had over 16 years' experience and was regarded as diligent and careful by his colleagues. The surgeon had over 30 years' experience; he set up the department. The other anaesthetist had additional skills pertaining to difficult airways. And the other three staff were all experienced in theatre. If this emergency had to occur, then this would have been the best team and the best place for this to happen.

But from ten minutes and for a further fifteen minutes the doctors fixated on intubation. The protocols and procedures were apparently ignored or forgotten.

Twenty-five minutes in, the point at which Elaine had been without air for over 20 minutes, they eventually stabilised her for a short time. Her oxygenation then fell for a further 10 minutes.

Thirty-five minutes in, they made the decision that they were going to abandon the operation for the day and let her wake up naturally. She was handed over to the recovery team. They left to continue with their operating lists.

But Elaine did not wake up. She showed signs of brain damage. Eventually under the care of a third anaesthetist she was transferred to the intensive care unit, but it was too late.

In his own words, the lead anaesthetist "lost control". There was a dispute among the team about who they felt was in charge. Their decision making had become fixated. Probably under the stress, they just couldn't think of other options.

The situational awareness of what was happening, what it meant and what needed to happen was different among the doctors. Communication dried up.

The story for the assistants and nursing staff was very different. They were generally aware of what was happening and what needed to happen, but to quote from the Inquest "didn't know how to broach the subject".

I was shocked, not just be the tragedy that had befallen me and my children, but as an independent report and inquest revealed, the system that had inadvertently killed my wife seemed to be so far behind in its practices. When it came to safety and human factors, it was as if it was stuck in the 1930's.

When we think about the term 'work-as-imagined', we front-line practitioners tend to think further upstream to directors, CEOs, senior policy makers, even politicians, as well as procedure writers, designers, engineers and others who are between the sharp and blunt ends of organisations. Indeed, we do need to help those who are not at the sharp end to understand the complex operational reality of work-as-done, in terms that people can understand. 'Work-as-imagined' and 'work-as-done' is one simple way of looking at work that anyone can understand. Importantly, it reminds us of what kind of work people are looking at: work-as-imagined or work-as-done?

> When we think about the term 'work-as-imagined', we front-line practitioners tend to think further upstream.

But it's not just about 'them'. As clinicians the world over have reviewed my late wife's case, in a quiet break room perhaps, they have all, with very few exceptions stated clearly: "I wouldn't have done what they did". Yet place those same people in a simulated scenario with the same real world disorder, most actually do. This gap illustrates the difference between work-as-imagined and work-as-done, but this imagination is that of those who do the work. And of course, the clinicians involved in Elaine's operation did not imagine that what happened would happen. As Erik Hollnagel (2016) stated, especially when something goes wrong, "work-as-done differs from what we imagine we would do in the same situation, but thinking about it from afar and assuming more or less complete knowledge".

Additionally, on the day, there were different 'imaginations' of what was happening and what needed to happen at that time, but these somehow could not be brought out into the open.

> How many times have you watched an incident replayed, and thought, "I wouldn't have done what they did"?

Of course this gap exists in aviation as well. How many times have you watched an incident replayed, and thought, "I wouldn't have done what they did"? And experience suggests that we may be the harshest critics of work-as-done by fellow professionals.

As front-line professionals, we need to understand that we do not simply represent the reality 'work-as-done'. We also imagine what others do and what we would do – even what we really do now. Whether we are thinking of the past, present, or future, we can all fall into the trap of imagining something better or different to reality.

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As front-line professionals, we need to understand that we do not simply represent the reality 'work-as-done'. We also imagine what others do and what we would do – even what we really do now. Whether we are thinking of the past, present, or future, we can all fall into the trap of imagining something better or different to reality. And as illustrated above, this is often far off the mark. But by paying more attention to the gaps between work-as-imagined and work-as-done – whether the imagination is that of others' or our own – we have a chance. ⑤

Martin Bromiley OBE is an Airline Captain and Founder of the Clinical Human Factors Group (CHFG), UK.

See Martin Bromiley talk in the video 'Just a Routine Operation' at https://vimeo.com/86978963.

The author wishes to acknowledge the contribution of Steven Shorrock in the development of this article.

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IMAGINING WORK-AS-DONE IN SIMULATION:
LESSONS FROM HEALTHCARE

Simulation is common to both healthcare and aviation. Part of the aim is to explore and address the gap between work-as-imagined (by simulation participants and others) and work-as-done. In healthcare, simulation includes diverse teams and difficult situations, making psychological safety a priority. In this article, **Michael Moneypenny** outlines some useful lessons.

KEY POINTS

1. Simulation aims to invoke work-as-done, but requires imagination. It allows us to facilitate participants' personal learning journeys from their own work-as-imagined to work-as-done.

2. For effective learning, it is necessary to create the conditions for psychological safety. What is said in the briefing is critical.

3. Simulation allows us to highlight problematic aspects of equipment, processes, systems and the environment.
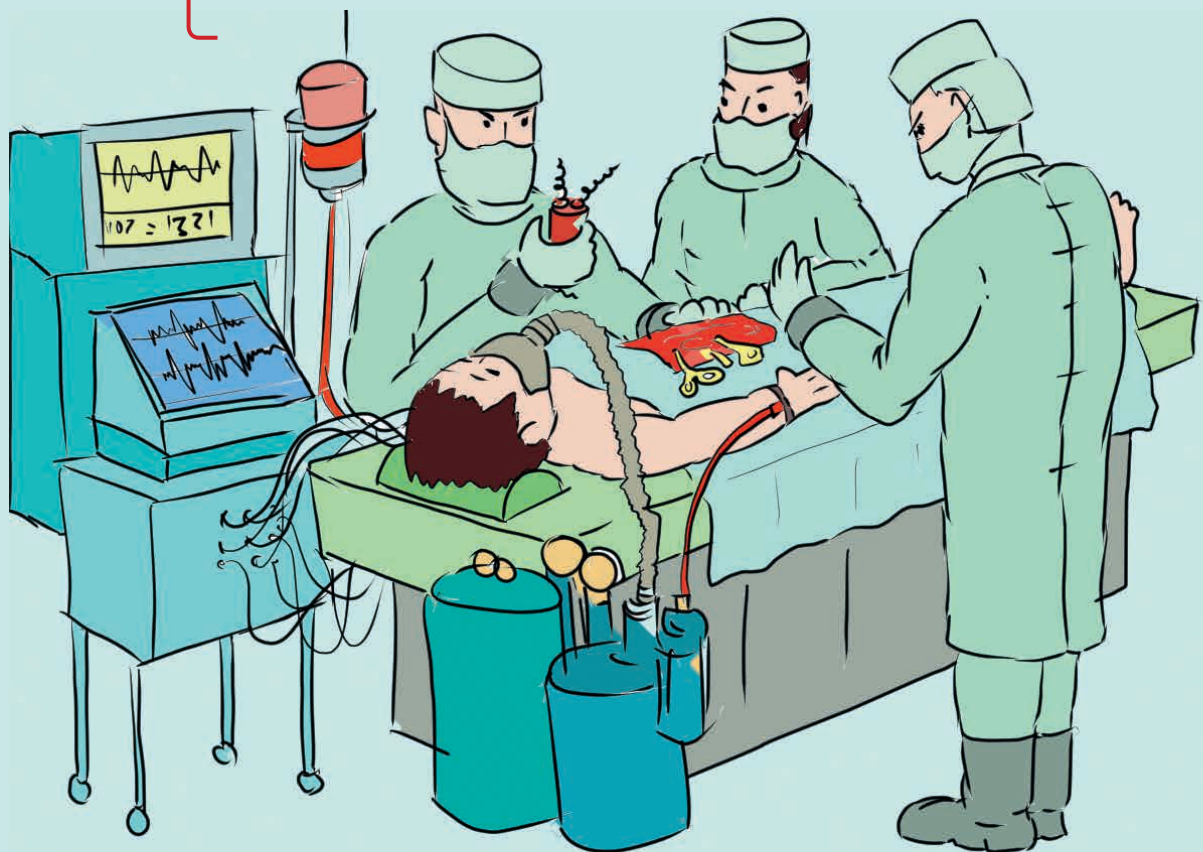
Are you sure this is the pacemaker and not buzzer form the last similations?

Simulation occupies a unique domain in the industries in which it is employed for learning and assessment. The aim in simulation delivery is not for 'the real' but for realism; not for making scenarios as real as possible but rather as realistic as necessary to invoke 'real-life' behaviour. Yet all simulation requires a suspension of disbelief and a degree of imagination by the participant, who must become immersed in the scenario they are faced with. In this twilight where the real, the realistic and the make-believe intertwine we can gain some insights into 'work-as-imagined' (WAI) and 'work-as-done' (WAD).

Realising personal performance gaps: Life-threatening asthma

One of the most powerful rationales for using simulation is that it allows us to facilitate participants' personal learning journeys from their own WAI to WAD. Asthma is increasing in prevalence and most attacks are easily treated with an inhaler. However some attacks worsen into life-threatening asthma, which will lead to death if not diagnosed and managed quickly and effectively. Most final year medical students are able to explain the investigations, the management options, and the need for early intensive care input. The students may rate themselves fairly high in terms of confidence in dealing with this imaginary scenario. Place those same students into an immersive simulation, with a 'patient' (mannequin) whose saturations are falling and who is unable to complete sentences, and the results are very different. The call for help is often late or never carried out as the student is too busy dealing with the problem at hand and cannot project into the future. Important investigations are omitted while inessential ones become a focus of attention. Within a safe learning environment this experience is a lightbulb moment for the student: they appreciate the disconnect between the theory and the application, between the seemingly straightforward WAI and the messy WAD.

Psychological safety and briefing the participants

In healthcare simulation our first concern is the psychological safety of the participants. Participants are often under stress because they are unsure of how well they will perform (WAD) and how well this will correspond to the image they have of themselves (WAI). A presentation slide on the Scottish Centre for Simulation and Clinical Human Factors faculty development course states: "Prioritise your relationship with the learners above the content of the course". Creating a safe learning environment serves a number of functions. The safe learning environment means that people will engage with the simulated scenario, performing as they would 'in real life', rather than focusing on the elements which are not realistic. During the post-scenario debrief, the safe learning environment fosters additional engagement; people will discuss their own mistakes, be open to critique from others and be willing to critique others' performance. The safe learning environment also creates the conditions that are a prerequisite for personal change: a lowering of defense mechanisms, the acceptance of personal fallibility and the belief in the possibility of improvement. Lastly, the safe learning environment helps to convince participants of the benefits of simulation as a learning technique and encourages repeated engagement. The 'difficult' quiet group of learners is often a result of a lack of perceived safety.

Psychological safety is created. It does not emerge naturally when a group of professionals get together, or are 'forced' to attend, for a learning experience. Psychological safety is established in a number of ways, which include:

- how participants are welcomed
- the environment in which the learning is to take the place
- the confidentiality of performance, and
- the briefing at the start of the day.

The briefing provides an opportunity to prepare participants for the unexpected, while at the same time instilling hope.

A typical briefing might include something along the lines of the following:

You may be wondering if you are going to make a mistake today in front of your colleagues.

Let me put your mind at ease.

You are going to make not just one mistake, but a number of mistakes today.

None of us, including me, perform as well as we imagine we will when placed under stress. This results in gaps in performance.

I have been involved in incidents in clinical practice which have led to patient harm and, a couple of times, contributed to a patient's death. Although I cannot be certain, I am convinced that for a number of those mistakes, had I made them in a simulated environment, I would not have made them with patients.

So today is an opportunity for all of us to make mistakes in a safe environment and to dissect those mistakes, so that we can learn from them and not repeat them in real life.

The briefing relaxes participants. They now know that their own WAI and WAD will be divergent, but that these gaps will be explored to improve their own performance.

Medical devices

As in aviation and ATC specifically, healthcare workers are surrounded by complicated devices. These devices can cause harm if used improperly. Simulation uses real equipment when this is essential for immersion. This means that the stressful simulated scenario (WAD) can expose weaknesses in the design of medical devices, which may be difficult for the manufacturers to predict (WAI).

For anaesthetists, the primary piece of equipment is the anaesthetic machine. Anaesthesia is one of the safest medical specialties and this is reflected in the safety mechanisms built into the modern anaesthetic machine. One safeguard is the hypoxic guard, which prevents the delivery of fatal 100% nitrous oxide. Another safeguard is the pin-index system, which prevents the potentially fatal swapping of gas cylinders. However, design weaknesses still exist. For example a well-known anaesthetic machine manufacturer
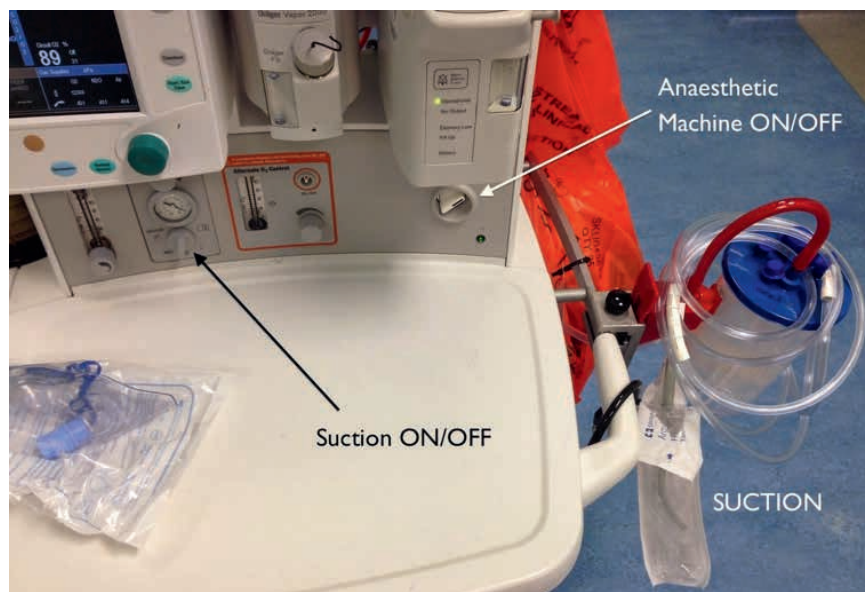
Figure 1: Anaesthetic machine.

had placed the on/off switch on the front, right-hand side of the machine. In everyday use, this anaesthetic machine is switched on in the morning and then not switched off again until the end of the operating day. Many machine set-ups also have the airway suction canister, tubing and stylet (a slender probe) attached to the right-hand side of the machine. The on/off switch for the suction is located on the front of the machine, in the middle. During everyday operations, the suction is used to clear a patient's airway of secretions before removing the endotracheal tube that is delivering gases and protecting the airway. In a crisis, the suction might be used to clear an airway that was not protected and had been soiled with stomach contents.

Over the course of several years, during simulated crises, we had observed participants switch off the anaesthetic machine when they had wanted to switch on the suction. This means that not only did the anaesthetist still not have the means to clear the airway but they also now also had an anaesthetic machine that required some minutes to restart. After discussions with anaesthetists it was discovered that the same mistake had been known to occur in real life. The machine manufacturer has since installed a lid on top of the on/off switch as a barrier to inadvertent use. (However, given that the switch is only used twice a day the better solution would be to place it out of immediate reach on the back of the machine).

A multitude of similar weaknesses are hidden within other medical devices, waiting for the right conditions to reveal their harmful consequences. Immersive simulation allows us to observe situations and behaviours in a single day, which the average anaesthetist may not see in many years of practice. Unfortunately, medical device manufacturers are failing to use immersive simulation to identify the gap between their WAI and the actual WAD.

Testing of systems and processes

Healthcare has a complex system of regulatory bodies, providers, training organisations and interest groups. This means that systems and processes are varied. For example, in most of the UK (Scotland has made some advances in standardisation) the only ubiquitous piece of paperwork is the death certificate. Everything else – anaesthetic charts, drug charts, fluid charts, admission records, operating notes, observation records, etc. – vary from hospital to hospital. Hospital processes vary similarly. Every hospital has a major haemorrhage protocol. This is put into action if a patient is at risk of dying due to blood loss, and results in different people being informed and different procedures being triggered in each hospital. The protocols are often wordy documents – rarely accessed and quickly forgotten – and the major haemorrhage protocol requires coordination between people who

rarely work together. This means that those who write the protocols (usually a committee of interested parties) are only able to invoke WAI in the creation process. When the major haemorrhage protocol is activated in real life, the people involved make the system work despite its limitations. Without dedicated observers, lessons are not learnt for future activations. It was only when the major haemorrhage protocol was tested repeatedly at the point of care, using the actual staff in their own work environment, and when WAD replaced WAI, that major flaws in the process were identified and rectified.

Final thoughts

The concepts of WAI and WAD help illustrate how simulation can be used effectively for learning. They help to point our own performance gaps and help to maximise learning by creating a psychologically safe learning environment. Drawing on these concepts, simulation can be used proactively to improve patient safety through device design and process testing. Concepts fulfil their purpose when they are useful in everyday practice and deepen our understanding of the complex systems in which we work. By these measures, work-as-imagined and work-as-done are valuable additions to our vocabulary.

Dr Michael Moneypenny has degrees in Biochemistry and Medicine, and an MD in Medical Education. He has worked as a consultant in Anaesthesia and is director of the Scottish Centre for Simulation and Clinical Human Factors (http://scschf.org/). His interests include the power gradients in healthcare, systems approaches to patient safety and the most effective methods for delivering simulation-based medical education. Dr Moneypenny is also Chair of the Scottish Clinical Skills Network.
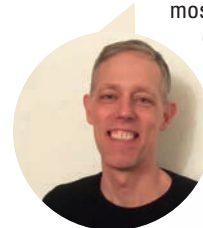
THE PROBLEM OF
MANY IMAGINATIONS

Healthcare often looks to aviation to learn about safety, but the two fields are fundamentally different in many ways. Healthcare is innovative, with many highly skilled front line professions who often favour clinical judgement over standardisation.
This can bring a 'problem of many imaginations', as **Suzette Woodward** explains.

KEY LEARNING POINTS

1. **Innovation is good. In healthcare, it has extended our survival and saved many lives, but too much unnecessary variation as a result has led to avoidable and preventable patient harm.**

2. **Judgement can be enhanced by rules, frameworks and checklists as long as they are used to create a safety net that prevents things from going wrong, and not simply complied with as an administrative task.**

3. **Policymakers and others should create guidance only if they truly understand the way work is currently done; the people, the culture and the conditions in which the guidance will be implemented.**

Picture walking into an anaesthetic room and being offered a large glass of whisky before being taken into the operating room to have your hip replaced. In the early days of medicine this was exactly the way in which patients would have been anaesthetised. Now consider a world without antibiotics or small pox vaccine or paracetamol. Comparing medicine in the 1950s with the 1990s, Professor Chantler once said, "Medicine used to be simple, ineffective and relatively safe. It is now complex, effective and potentially dangerous".

So we have transformed healthcare from these early days to an astonishing industry that improves the lives of many.

This is through a constant challenge of the status quo. Innovation and improvement is in our genes, it is at the very heart of what we do. We try to do the very best for our patients while constantly moving healthcare forward.

Innovation and improvement is in our genes, it is at the very heart of what we do.

An early innovator Florence Nightingale, who is clearly known for being at the forefront of nursing and nurse training, was also one of the earliest patient safety thinkers and statisticians. In the mid-1850s she noticed that many of the soldiers were dying in ways that she intuitively thought were avoidable. She plotted all of the reasons why soldiers died in the army in the Crimean War from April 1854 to March 1855 and found that most of the soldiers' illnesses were caused by what she describes as 'defects in the system'. She deduced that perhaps at least one in seven of the patients (around 14%) died from preventable diseases rather than their

battle wounds. As a result of this work she made huge improvements to the way the soldiers were being cared for. These were not isolated interventions but fundamental aspects of care; good nutrition, warm clothing, and good ventilation, and most importantly cleanliness and hand hygiene (Woodward, 2017).

Ignaz Semmelweis was a Hungarian physician who, around the same time as Nightingale in the 1850s, wanted to understand why some of his patients died after childbirth. In his first publication, Semmelweis described the tale of two maternity clinics at the Viennese hospital in which he worked. The first clinic had an average death rate, from infection called puerperal fever, of around 10%. The second clinic's rate was lower, averaging less than 4%. Interestingly, this fact was known outside the hospital and the women begged to be admitted to the second clinic. Semmelweis described how desperate women were begging on their knees not to be admitted to the first clinic. In fact some women even preferred to give birth in the streets.

Semmelweis was puzzled and deeply troubled by the fact that puerperal fever was rare among women giving street births and that the first clinic had a much higher mortality rate. The two clinics used almost the same techniques, and Semmelweis started a meticulous process of eliminating all possible differences between them. He excluded a variety of potential causes; the only major difference was the individuals who worked there. The first clinic was the teaching service for medical students, while the second clinic had been selected in 1841 for the instruction of midwives only. He proposed that the cause was in fact the doctors and medical students, who were routinely moving from the task of dissecting corpses to examining new mothers without first washing their hands. They transferred infections from the corpses to the mothers, and women died as a consequence. The midwives were not engaged in autopsies.

Semmelweis issued a policy of washing hands between autopsy work and examination of patients. The result was the mortality rate in the first clinic dropped by 90%. When the doctors, medical students and midwives washed their hands, the number of deaths from infections went down. What happened next is as interesting as his findings. Despite seemingly compelling evidence that mortality reduced to below 1% from between 10% and 35%, his ideas were rejected. His observations conflicted with the established views at the time. Semmelweis not only failed to convince clinicians enough to change their practices, he angered and offended them. In fact there is today a phrase that has been used to describe his challenge which is named after him: the Semmelweis reflex. This is used as a metaphor for a reflex-like rejection of new knowledge because it contradicts entrenched norms and beliefs. This is not limited to healthcare.

> The Semmelweis reflex is used as a metaphor for a reflex-like rejection of new knowledge because it contradicts entrenched norms and beliefs.

The desire to constantly improve, innovate and change impacts on patient safety in a number of ways. We need to look at the consequences of the problem of many imaginations. These include the following three problems.

There are too many ideas, guidance and findings.

One problem concerns the sheer volume of material to keep up with. In healthcare we are drowning in new ideas, new guidance and research findings; in a world of two million articles a year which ones do you read, which ones do you trust, which ones do you have time to implement?

There is too much unnecessary variation

A second problem concerns variation between actors. Clinical judgement is used as an excuse for variation: "I'm doing it my way". This variation can be a significant risk to patients. Clinicians sometimes believe that they have a right to autonomy above all else. This

> There is an intrinsic desire to reject rules and regulations that clinicians feel may prevent them working differently from others.

means that one surgeon performing a tonsillectomy can carry out the procedure in a very different way from another surgeon doing exactly the same thing, even within the same hospital. It also means that rather than see all doctors and nurses as equal, and feel safe in everyone's hands, patients instead ask, "Who is doing my operation today?". There is an intrinsic desire to reject rules and regulations that clinicians feel may prevent them working differently from others.

This clinical judgement also means that solutions that appear to undermine this judgement are ignored. This is the story of the World Health Organisation (WHO) surgical checklist. A core checklist was designed in 2006 which allowed individual teams to adapt it to fit with their environment. This task was being led by Atul Gawande, a surgeon from the US. His later book The Checklist Manifesto; how to get things right (Gawande 2009) beautifully described the challenges people face in implementing checklists. The checklist was, on the face of it, a list of things to check off prior to surgery. However, it was clearly more than a list. Properly used, the checklist ensures that critical tasks are carried out and that the whole team is adequately prepared for the surgical operation. During the implementation process, in the main, anaesthetists and nurses were largely supportive of the checklist but consultant surgeons were not convinced. There is currently huge variability in use and implementation. For example, implementing parts but not all, missing out a key component of the checklist or – even worse – completing all the checklists prior to the operating session to be put aside so that the team could 'get on with their day without having to worry about it'. Using checklists in healthcare is not a way of life and has become simply an administrative task. This is a classic 'work-as-imagined' versus 'work-as-done' story. The designers, managers, and regulators all believe that the checklist either happens or should happen, but the people at the frontline have used it or not used it in the only way they know how to get the job done.

There are too many local solutions

A third problem concerns the local approach to ideas and solutions. There can be reluctance to adopt or share new ideas or good practice, which prevents the ability to standardise across systems. For example, prescription sheets are different in every single hospital. How amazing would it be if there was one standard sheet to use across the whole of the healthcare system? Standardisation can reduce the wasted time and energy of individuals inventing solutions and creating their own tools rather than adopting and adapting generic tools or solutions developed by others. Dixon Woods and Pronovost (2016) point out the unintended consequences of creating local solutions such as different coloured allergy bands or labelling for drugs. When these are different from one hospital to another, then those that move around (in particular junior doctors) are confused and set up to fail as a result. The visual clues in one hospital that makes them safe can, in another hospital, make them unsafe.

Understanding people, culture and conditions

For us to move forward for the next decade or so, those that set standards, targets, policy and other directives need to make a concerted effort to understand the people, culture and conditions in which frontline workers are situated, and in which work-as-done is done. As Jim Reason says, when you go into a new environment find out everything you possibly can about that environment (Reason, 2015). Equally, frontline staff should also realise that there are some interventions (work-as-imagined) that could make a difference to their world, and enhance their ability to exercise judgement without creating a threat to their autonomy and their ability to innovate. ⑤

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Dr Suzette Woodward is the National Campaign Director for Sign up to Safety. She is a paediatric intensive care nurse who has worked for over 35 years in the NHS. With a doctorate in patient safety, she has worked for the last twenty years leading national patient safety programmes.

MORE VIEWS FROM ELSEWHERE

As this Issue of HindSight has shown, there are differences between different 'varieties of human work'. Some work is imagined or prescribed but not done. Other work is done but not imagined and perhaps not even disclosed. Still other work is done as imagined and as prescribed.

The following vignettes have been provided by healthcare professionals to illustrate some of the relationships between the different varieties of work shown in Figure 1.

As you read the vignettes, consider your own work. Do any similar situations come to mind?

Work-as-Imagined   **Work-as-Prescribed**

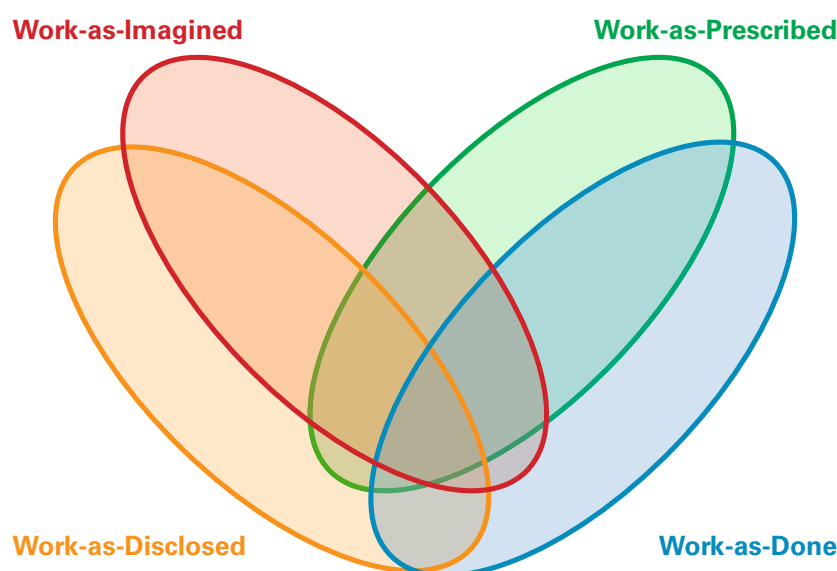**Work-as-Disclosed**   **Work-as-Done**

Figure 1. The varieties of human work (From http://bit.ly/TVOHW)

How do work-as-imagined, work-as-prescribed, work-as-done, and work-as-disclosed interact in aviation?
If you would like to submit a vignette that may be published anonymously in future editions of HindSight, please contact
steven.shorrock@eurocontrol.int
with a vignette of 200 words or less.

Of the 2184 policies, procedures and guidelines (PPGs) in my organisation, 28% are currently out of date and may therefore not reflect current practice. More interesting still, are the nearly 19% of PPGs that have been opened less than 5 times in total, including by their authors. These documents are often written to meet the requirements of external agencies with the idea that not having a policy leaves the organisation vulnerable to criticism. These documents remain unopened, unused and unrelated to daily work but may be used after incidents as a form of organisational protection: "yes, we had a policy for that".

Carl Horsley, Intensivist,
@horsleycarl

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In operating theatres that use lasers, certain rules and safety precautions have to be in place. Part of this is to have a risk assessment and standard written laser protection policy. This risk assessment is normally carried out by a laser protection supervisor from a distant site who has no knowledge of local practice. In addition, this tends to be written when a new laser is purchased and then is never updated. While work-as-imagined would be following the policy to the letter, if the policy is impractical for the local use of the laser, the local team will tend to develop workarounds. When there is a site visit by the laser protection supervisor, work-as-disclosed will follow work-as-imagined – as they are reassured that everyone follows all the rules to the letter. If a laser protection incident does however occur, the local team would all be held to account by the defunct laser protection rules.

Craig McIlhenny, Consultant Urological Surgeon,
@CMcIlhenny

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The computerised estimation of the time it will take to perform a case in theatre can be an example of 'projection'. Theatre scheduling uses the average time that similar cases have taken in the past to predict how long a case will take in the future. Individual patient, surgical and anaesthetic factors are not considered. Sometimes this is accurate, but other times it is not. It is therefore a crude system, although it is the best that we have at present. The problem comes when staff feel they have failed when cases take longer than the projection and theatre over runs. This is inevitable given the nature of the system.

Emma Plunkett, Anaesthetist,
@emmaplunkett

The WHO Surgical Safety checklist was introduced into the National Health Service following the release of Patient Safety Alert Release 0861 from the National Patient Safety Agency on 29 January 2009. Organisations were expected to implement the recommendations by February 2010 including that "the checklist is completed for every patient undergoing a surgical procedure (including local anaesthesia)". All organisations have implemented this Patient Safety Alert and the WHO Surgical Safety checklist is an integral part of the process for every patient undergoing a surgical procedure. Whilst the checklist appears to be used in every patient, there is clear evidence that there is variability in how the checklist is used both within an organisation and between organisations. Within an organisation, this variability can occur between teams with differences in the assumed value of using the checklist and within a team between individuals or professional groups. Its value can degrade to a token compliance process to 'tick the box'. The assumption within an organisation at 'the blunt end' is that it is done on every patient.

Alastair Williamson, Consultant Anaesthetist,
@TIVA_doc

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There are high levels of burnout. A target-driven culture is exacerbating this problem. A typical example was when the government seemingly became convinced by poor quality data which suggested that dementia was under diagnosed. So it decided to offer GPs £55 per new diagnosis of dementia. Targets were set for screening to take place – despite the UK National Screening Committee having said for years that screening for dementia was ineffective, causing misdiagnosis. And when better data on how many people had dementia was published – which revised the figures down – it was clear that the targets GPs were told to meet were highly error-prone. The cash carrot was accompanied with beating stick, with the results – naming and shaming supposedly poorly diagnosing practices – published online. Setting doctors harmful tasks, leading them almost to "process" patients, fails to respect patient or professional dignity, let alone the principle of "do no harm". [Extract from article 'The answer to the NHS crisis is treating its staff better', New Statesman, 13 Feb 2017]

Margaret McCartney, General Practitioner,
@mgtmccartney

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When preparing intravenous injections for a patient, guidelines (e.g., NMC medicines management guidelines) and procedures require that the injection must be prepared immediately before it is due to be given, and not prepared in advance of this time. However, under current service pressures, including staff shortages and high acuity, doses may be prepared in advance to save time, or if prepared on time and then for some reason not given, may be stored to one side for later use, instead of being disposed of and re-made at a later time.

Anonymous, Pharmacist

A Do Not Attempt Resuscitation (DNAR) form is put into place when caregivers feel that resuscitation from cardiac arrest would not be in the patient's best interests. These forms have received a significant amount of bad press, primarily because caregivers were not informing the patient and/or their families that these were being placed. Another problem with DNAR forms is that some clinicians feel that they are being treated as "Do Not Treat" orders, leading (they feel) to patients with DNAR forms in place receiving sub-standard care. This means that some patients who would not benefit from resuscitation are not receiving DNAR forms. As a result, when these patients have a cardiac arrest they are subjected to aggressive, yet ultimately futile, resuscitation measures which may include multiple broken ribs, needle punctures in the arms, wrists and groin, and electric shocks. It is not unusual to hope that these patients are not receiving enough oxygen to their brains to be aware during these last moments of their lives.

Anonymous, Anaesthetist.

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R Radiology request forms are meant to be completed and signed by the person requesting the procedure. In the operating theatre, the surgeon is usually scrubbed and sterile, therefore the anaesthetist often fills out and signs the form despite this being "against the rules". Managers in radiology refused to believe that the radiographers carrying out the procedures in theatre were "allowing" this deviation from the rules.

Anonymous.

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C Certain clinical situations are volatile, uncertain, complex, ambiguous (VUCA) and time critical and they can highlight different aspects of 'the messy reality'. For example, a patient with a ruptured abdominal aortic aneurysm, if they reach hospital alive, will require immediate transfer to theatre for the life-threatening bleeding to be stopped and a new vessel to be grafted into place. The complex and dynamic nature of the case deems that it cannot be prescribed and so the practitioner has to operate within the discretionary space. This allows the practitioner the necessary freedom to treat the changes as they arise and potentially to deviate from 'standard operating procedures' (SOPs). These SOPs are ordinarily designed for non-emergency work and have a number of 'safety steps' inherent within them. There are important steps such as identifying the patient, procedure and allergies and form part of the wider WHO 'five steps to safety' but also other points less critical but important, especially in the non-emergency setting. It is commonplace for the practitioner to deviate from the SOPs and to perform an ad-hoc, yet necessary, streamlining of this process in order to proceed at the appropriate pace and to treat physiological changes as they present themselves. This can give rise to a number of issues. Firstly, I have known this deviation to create friction amongst the team at this critical time that is

generally not helpful in both proceeding with the work and maintaining team harmony. Secondly, if the outcome for the patient is poor and the case is investigated, I have known for practitioners to be admonished for their deviation from the SOPs, although they nominally relate to the non-emergency setting. This is in stark contrast to if there is a good patient outcome as the deviation is often not even noted, or highlighted as potentially being intrinsic to the positive outcome. Lastly there is often a corporate response that seeks to prescribe the work that is by definition VUCA and cannot be prescribed. Ultimately, I believe that, on balance, practitioners benefit from 'the messy reality' as it is when the work is at its most complicated and cannot be prescribed that autonomy and professional judgment can be exercised most readily for the benefit of the patient.

Dr Alistair Hellewell, Anaesthetist, @AlHellewell

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T The 'normalised' unsafe practice of hyperventilation during cardiac arrest management provides a comprehensive example of 'the messy reality'. It has become evident, from analysing retrospective observational data, that during the procedure of cardiopulmonary resuscitation (CPR), medical practitioners (usually anaesthetists) almost always deliver too much pressurised oxygen/air to the lungs of patients (both adults and children). Traditional Safety-I concepts may regard this as a 'violation', in that that this practice continues to occur despite a succession of recommendations in international guidelines to the contrary, supported by the established and widespread provision of systematic, organised education and training. However, when directly questioned, anaesthetists demonstrate a clear, functional knowledge that such practice is detrimental to patient outcome. When contemplating this behaviour we must consider the following. Firstly, there is no intention for airway management practitioners to deliberately hyperventilate a patient. Secondly, these clinicians do not know that they are hyperventilating patients during the period that it is actually happening. Thirdly, there is not ordinarily any recognition or acknowledgement that they may have hyperventilated the patient after the clinical intervention has been discontinued. Despite the fact that this issue is widely known to anaesthetists, others (particularly at the blunt end) would generally be ignorant of the issue.

Ken Spearpoint, Emeritus Consultant Nurse, @k_g_spearpoint

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These vignettes, and more, can be found at www.humanisticsystems.com as part of a series entitled 'The Archetypes of Human Work' (see http://bit.ly/TAOHW1).

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A PLOT TWIST AT THE OSCARS

Even when we imagine that something extraordinary is actually possible, reality can have other ideas. This was the case with finale of The Oscars 2017, when design flaws and operational pressures collided. The ensuing plot twist reveals some truths about design and operation, as **Steven Shorrock** explains.

KEY POINTS

1. What we casually label as 'gaffes' and 'blunders' are usually deeply rooted in the design of artefacts and in the context of design and operation.

2. Gaps between work-as-imagined and work-as-done, and between designers' and users' mental models, can have unintended and unimagined consequences.

3. The (initial) cost of design flaws is compromised decision making at the sharp end, including compensatory trade-offs.

4. Under time pressure and with degraded information, it can be difficult to give voice to our doubts, uncertainties and concerns.

THE
OSCARS

LA LA LAND
EMMA STONE, ACTRESS

Best actress

"An extraordinary blunder"

It has been described as *"an incredible and almost unbelievable gaffe"* (Radio Times), *"the greatest mistake in Academy Awards history"* (Telegraph), *"an extraordinary blunder…an unprecedented error"* (ITV News), and *"the most awkward, embarrassing Oscar moment of all time: an extraordinary failure"* (Guardian).

It was, of course, the Grand Finale of the Oscars 2017.

Faye Dunaway and Warren Beatty are all set to announce the best picture win. Beatty begins to read out the winner's card. But he looks visibly puzzled, pausing and looking in the envelope to see if there is anything else that he's missed. He begins to read out the winner's card, *"And the Academy Award…".* He pauses and looks in the envelope again. *"…for Best Picture".* He looks at Dunaway, who laughs *"You're impossible!"*, and he hands the card to her. Dunaway, perhaps assuming this is all for effect, simply reads out what she sees, and announces, *"La La Land!".*

The La La Land team exchange embraces and walk to the stage and start to deliver thank-you speeches. But the winner's envelope is, in fact, the envelope for best actress, just given to La La Land's Emma Stone.

Behind Beatty, the Pricewaterhouse-Coopers overseers – Brian Cullinan and Martha Ruiz – are on stage, examining the envelopes. Producer Jordan Horowitz takes command, *"I'm sorry, there's a mistake. Moonlight, you guys won Best Picture".* Confused claps and cries ensue. *"This is not a joke",* Horowitz continues. Beatty now has the right card, but Horowitz takes it out of Beatty's hand and holds it up to show the names of the winning producers.

Beatty tries to explain his local rationality, and is interrupted by host Jimmy Kimmel, who betrays an assumption of responsibility: *"Warren what did you do?!"*. Beatty continues, *"I want to tell you what happened. I opened the envelope and it said, 'Emma stone – La La Land'. That's why I took such a long look at Faye and at you. I wasn't trying to be funny"*. Horowitz hands his Oscar to Barry Jenkins, Moonlight's director.

It was *"the first time in living memory that such a major mistake had been made"* (Reuters). The accountancy firm PriceWaterhouse-Coopers apologised and promised an investigation. In a statement, they said, *"The presenters had mistakenly been given the wrong category envelope and when discovered, was immediately corrected. We are currently investigating how this could have happened, and deeply regret that this occurred. We appreciate the grace with which the nominees, the Academy, ABC, and Jimmy Kimmel handled the situation".*

Design-operation gaps

The design of the envelopes for the awards was new, and far from ideal. The text was gold on a red background: form over function. The previous design was black text on a white background. Once the envelope was opened, there was little to help Beatty and Dunaway spot the problem. At the top of the card was "The OSCARS" logo. In the middle of the card was the name of the movie and the names of the individuals, all in capitals: "LA LA LAND, EMMA STONE, ACTRESS". This would have been a source of confusion for Beatty. The all-important category was in a tiny, feint, italic serif font, below a line at the bottom of the card.

Aviation has taken huge steps to optimise typefaces, symbols and displays. Design consultant and ex-RAF officer Dave Cochrane wrote about the importance of visual communications design in aircraft piloting systems. He wrote that "Typography, and the screen technology it is presented on, has a very powerful influence on how we absorb, retain, and process information". But we should not consider the matter closed. Jean-Luc Vinot and Sylvie Athènes from the University of Toulouse, cited by Cochrane, stated that "the large number of available digital fonts, as well as the published guidelines should not lead us to consider that legibility is no longer an issue of concern". The issue has plagued control centres in the past (e.g., BBC, 2002).

In healthcare, the issue remains an everyday hazard in medicine packaging, where medicine names look alike or sound alike or have very similar labels for different drugs or doses. Many packages and labels require users to force attention onto small details of text, perhaps with the addition of a small area of colour which, on its own, is quite inconspicuous. It is asking a lot of people to make critical – sometimes life-and-death-critical – decisions based on small design features when the potential for confusion is so high. While aviation has schemes such as EUROCONTROL's call sign similarity service to reduce confusion at the blunt end, those on the front line of healthcare have to sort out this design mess at the sharp end.

Several coding methods (e.g., shape, colour, size) can help to make vital distinctions. In human factors/ergonomics, these are used as part of an iterative human-centred design process (e.g., ISO 9241-210:2010 – Ergonomics of human-system interaction – Part 210: Human-centred design for interactive systems) that seeks to understand stakeholders and context, identify user needs, specify design requirements, produce prototypes, and test them.

In the absence of this process, what is amazing is not that such 'extraordinary failures' occur, but that such failures are not much more ordinary. Because such failures occur infrequently, when they do happen they are often (and unhelpfully) branded 'human

error'. When considered more carefully, we can see that they are often, in large part, a problem of design. As Hollnagel (2016) states, "The bottom line is that the artefacts that we use, and in many cases must use, should be designed to fit the activity they are intended for" (p. 57). Understanding people, activities, contexts, and technologies is the bedrock of human factors and ergonomics (HF/E), but differences between design and operational contexts and activities contribute to gaps between how designers intend and imagine that an artefact or technology be perceived, understood and used, and how users actually perceive, understand and use the artefact or technology. In design,

work-as-imagined tends to be incorrect and incomplete with reference to work-as-done, especially for very complicated work. In operation, users' mental models (of technology) tend to be incorrect and incomplete, especially for very complicated technology. Even seemingly small gaps may have very large implications for operation, including interaction patterns not-as-designed and compensatory trade-offs and compromises in operation. Figure 1 shows differences between contexts and mental models in design and operation (see also Norman, 1988; Hollnagel, 2016).

Safeguards gone bad

At the Oscars, the design problem multiplied. Two identical sets of the winners' cards were made for 'safety purposes'. These duplicate envelopes were held in the wings in case anything
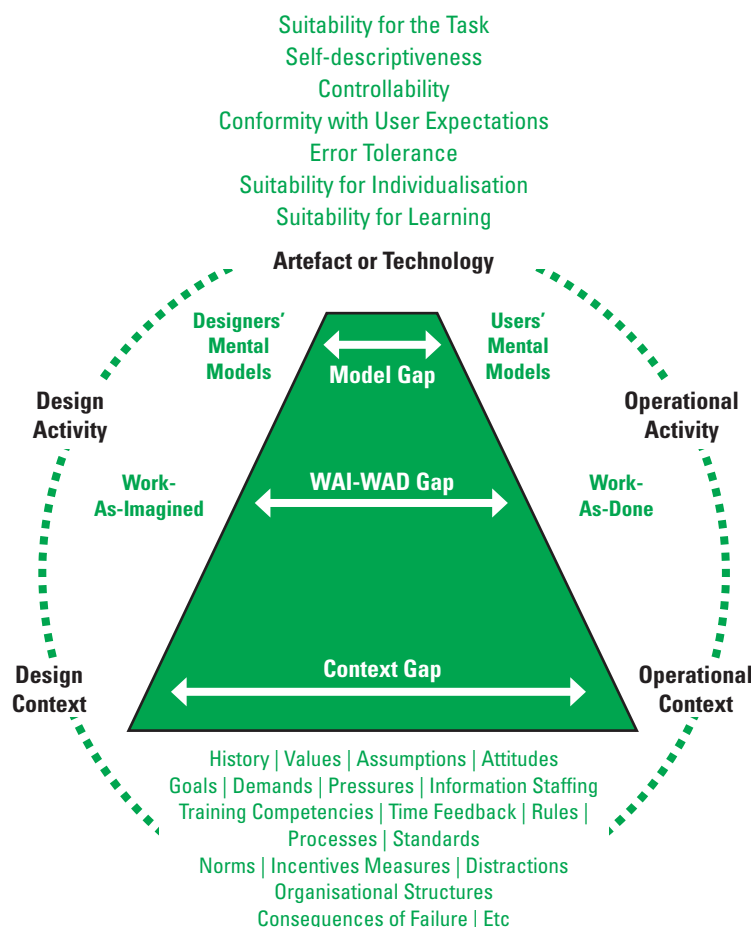
> Risk controls change the context and can have unintended consequences, introducing new risks.

should go wrong with a presenter or an envelope. In this case, the duplicate of the Best Actress award, which had just been announced, was handed to Beatty as he walked out to announce the Best Picture winner.

Safeguards feature in most safety-critical industries, and tend to result from risk assessments and safety investigations. When performed as linear cause-effect analysis processes, these often stop at the risk control. But risk controls change the context and have can unintended consequences, introducing new risks.

In this case, the spare set of envelopes was identical to the main set, like a fallback mode that looks identical to the main display. There were no other means of coding (e.g., colour, pattern) to indicate any difference.

We can see some parallels here in the beginnings of the discipline of human factors and ergonomics. Van Winsen and Dekker (2016) wrote that "A seminal study that set the agenda for the scientific discipline of human factors was by the experimental psychologists, Fitts and Jones (1947), who adapted their laboratory techniques to study the applied problem of 'pilot error' during WWII. The problem they faced was that pilots of one aircraft type frequently retracted the gear instead of the flaps after landing. This incident hardly ever occurred to pilots of other aircraft types. They noticed that the gear and flap controls could easily be confused: the nearly identical levers were located right next to each other in an obscure part of the cockpit" (p. 67).

Decision-making under uncertainty

The prospect of an erroneous announcement was clearly imaginable to Cullinan and Ruiz, who spoke to The Huffington Post about this scenario just a week or so before that fateful night: "We would make sure that the correct person was known very quickly", Cullinan said. "Whether that entails stopping the show, us walking onstage, us signalling to the stage manager — that's really a game-time decision, if something like that were to happen. Again, it's so unlikely."

Suitability for the Task
Self-descriptiveness
Controllability
Conformity with User Expectations
Error Tolerance
Suitability for Individualisation
Suitability for Learning

Artefact or Technology

Designers' Mental Models | **Model Gap** | Users' Mental Models

Design Activity | **Operational Activity**

Work-As-Imagined | **WAI-WAD Gap** | Work-As-Done

Design Context | **Context Gap** | **Operational Context**

History | Values | Assumptions | Attitudes
Goals | Demands | Pressures | Information Staffing
Training Competencies | Time Feedback | Rules |
Processes | Standards
Norms | Incentives Measures | Distractions
Organisational Structures
Consequences of Failure | Etc

Figure 1: Design-operation gaps with regard to artefacts and technologies[1].

Even when we imagine that something extraordinary is possible, reacting when that something does happen is another thing entirely. Many readers will be quite familiar with this, and it is an important reason for simulation. In this case, Beatty (and Dunaway, Cullinan, and Ruiz) were live on the night of the biggest show on earth, with the eyes of tens of millions upon them, recorded for perpetuity for viewing by hundreds of millions more. The announcement would feel like a gold Olympic medal to a few producers. That high-stakes, game-time decision that seemed so unlikely was now the real deal, and it wasn't handled quite as imagined. Imagined responses need to be tested in a simulated environment.

Decision-making under uncertainty is a normal feature of much safety-critical work. The information and situation may be vague, conflicting or unexpected. In some cases, there is a need to signal confusion or uncertainty, perhaps to get a check, or to ask for more time. When someone has a command position – in an operating theatre, cockpit or control room, or at the Oscars – it can be difficult for that person to indicate that they are not sure what is going on. Especially when under time pressure, it can be hard for us to give voice to our uncertainty in this way. This has played out in several aviation accidents and moreover in everyday life. But sometimes, it is necessary to send a message to colleagues along the lines of, "I don't understand what's going on. I need help". This

identifies a problematic situation and opens the door to other members of the team to help problem-solve. This kind of intervention is part of training programmes for team resource management, and can help everyone involved – no matter what their formal position – to voice and resolve their doubts, uncertainties and concerns.

It's just an awards show

The events of Oscars 2017 will be emblazoned forever on the minds of participants and aficionados. But it as host Jimmy Kimmel said, "Let's remember, it's just an awards show". For those who have to put up with the same sorts of issues every day, it's much more than that. In aviation and other industries, people help to ensure that things go well despite problematic aspects of the systems and environments in which they work. For the most part, the human in the system is less like a golden Oscar, and more like Mister Fantastic or Mrs Incredible, using abilities of mind and body to connect parts of systems that only work because people make them work. This aspect of human performance in the wild is usually taken for granted. But in the real world, people create safety. And for that, they deserve an Oscar. **S**

> For the most part, the human in the system is less like a golden Oscar, and more like Mister Fantastic or Mrs Incredible, using abilities of mind and body to connect parts of systems that only work because people make them work.

This article is adapted from *Human Factors at The Oscars and Just Culture in La La Land*, at www.humanisticsystems.com

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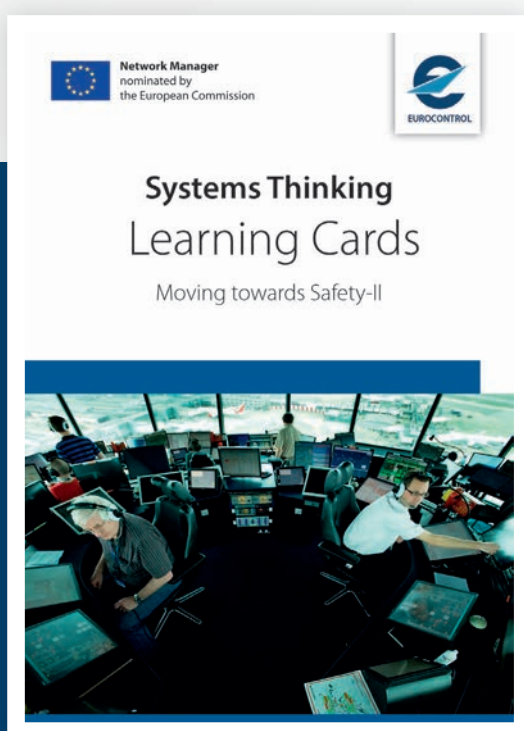
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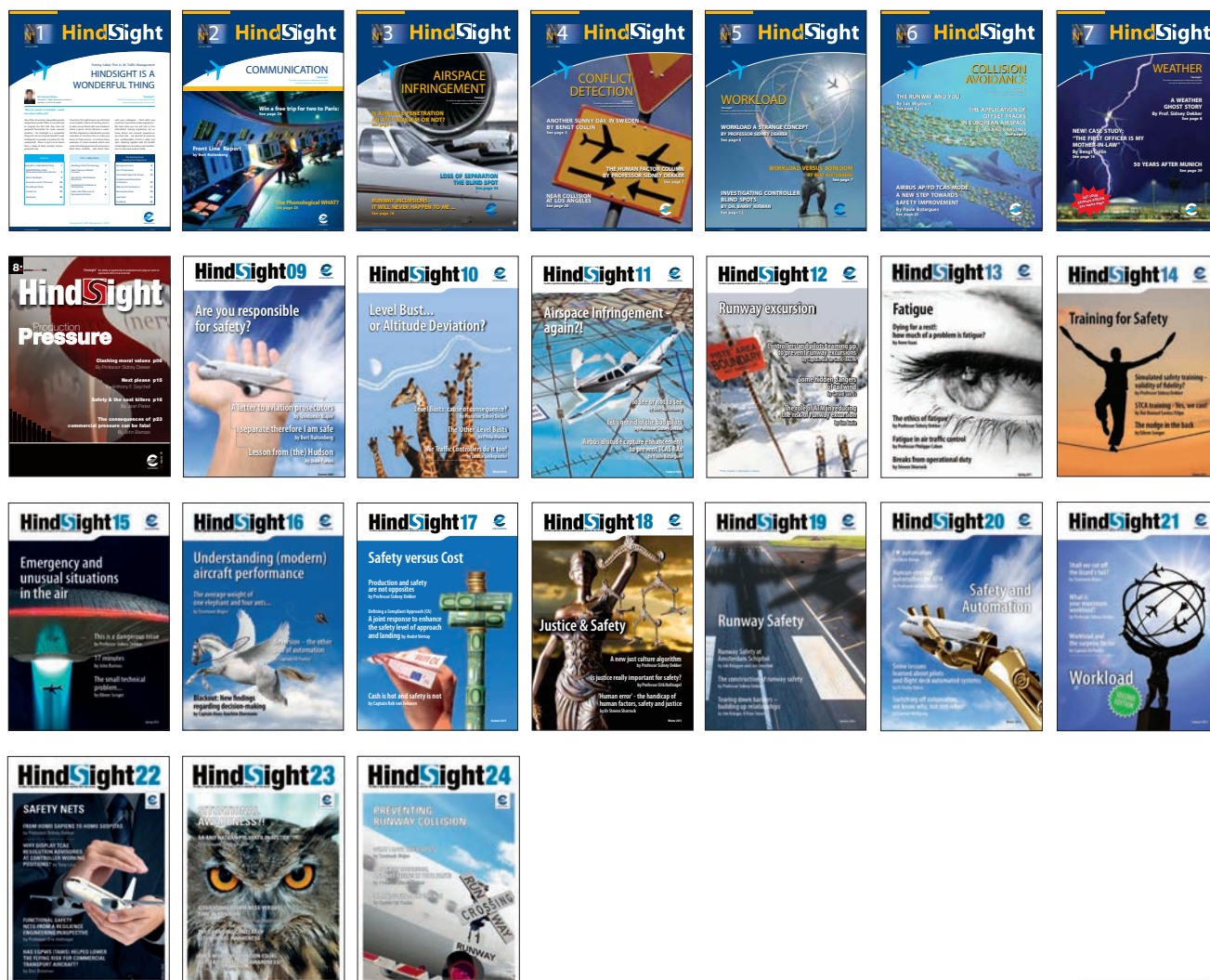
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