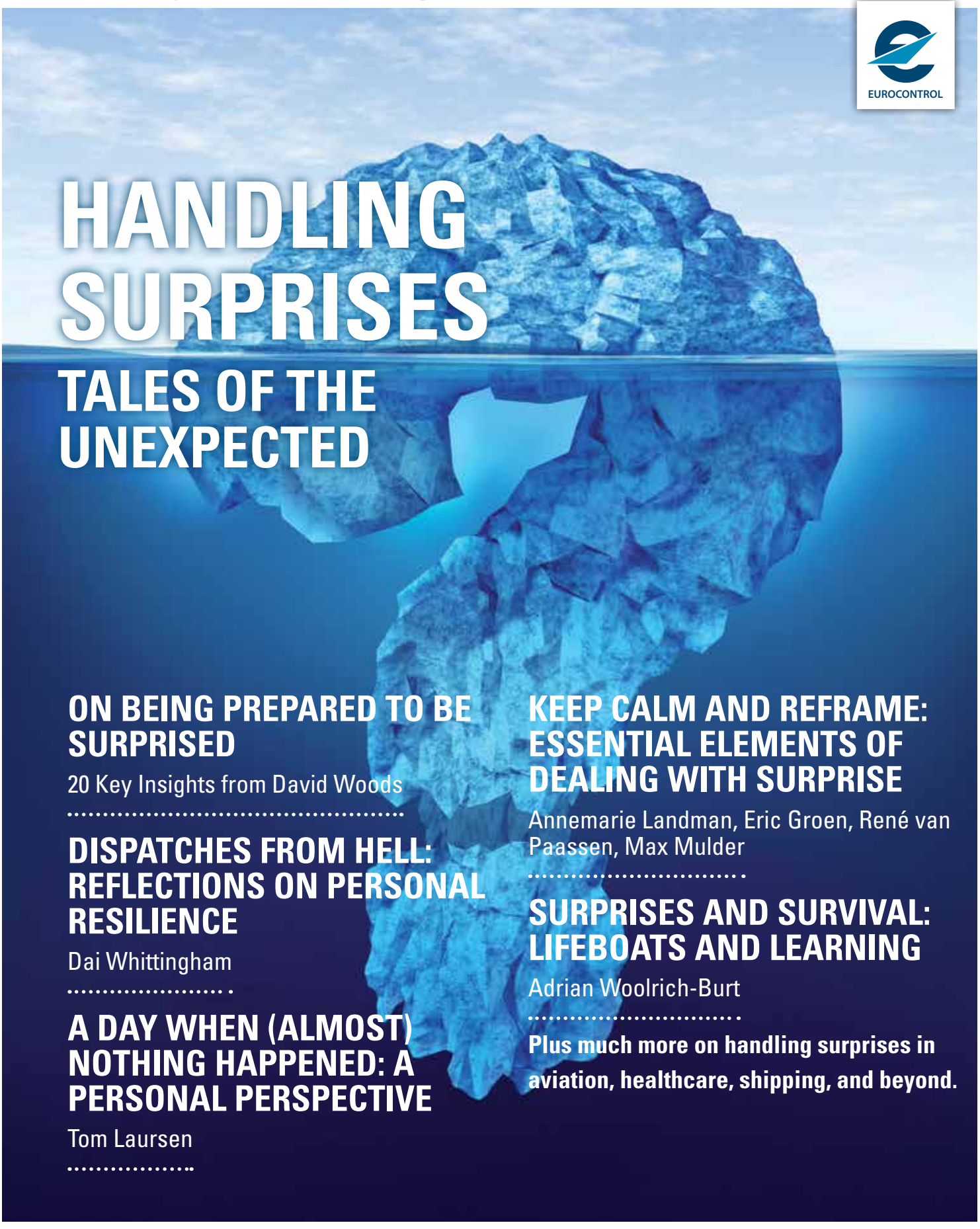
HindSight 34

Human and organisational factors in operations

EUROCONTROL



HANDLING SURPRISES

TALES OF THE UNEXPECTED

ON BEING PREPARED TO BE SURPRISED

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Plus much more on handling surprises in aviation, healthcare, shipping, and beyond.

Winter 2022-2023

WELCOME

Welcome to issue 34 of EUROCONTROL's *HindSight* magazine, the magazine on human and organisational factors in operations, in air traffic management and beyond.

This issue is on the theme of **Handling Surprises: Tales of the Unexpected**. You will find a diverse selection of articles from front-line staff, senior managers, and specialists in operations, human factors, safety, and resilience engineering in the context of aviation, healthcare, maritime, and web operations. The articles reflect surprise handling by individuals, teams and organisations from the perspectives of personal experience, theory, research, and training.

HindSight magazine emphasises the value of multiple perspectives, and there is often a tension between these. In this zone of tension, we can find much insight as well as reasons for different understandings. There are differences in perspectives within and between researchers, specialists, senior managers and front-line staff. What is surprise and how does it differ from startle, or simply 'the unexpected'? How do surprises emerge? How can we be prepared to be surprised at individual, team, and organisational levels? How should we respond after surprises? There is rarely one correct answer, and the topic itself is surprising.

In this packed issue, including the online supplement articles, leading voices from the ground and air, and from academia and other industries, share perspectives on these questions. I hope that the articles help you to prepare to be surprised. It is also recommended to review issue 15 of *HindSight* on Emergency and Unusual Situations in the Air.

Special thanks are extended to the authors and the operational reviewers, who help to ensure that *HindSight* magazine is relevant, interesting and useful. While the primary readers are operational staff, especially those involved in aviation, it is read much more widely, by different people in different sectors.

We hope that the articles trigger conversations between you and others. Do your operational and non-operational colleagues know about *HindSight*? Please let them know. Search 'SKYbrary HindSight' for all issues, covering a wide variety of themes.

The next issue of *HindSight* will be on the theme of **Just Culture…Revisited** (see inside back cover). What's your story? Let us know, in a few words or more, for Issue 35 of *HindSight* magazine.

Steven Shorrock, Editor in Chief of HindSight

Tony Licu
Head of Safety Unit, EUROCONTROL
Network Manager Directorate

MANAGING THE UNEXPECTED

Our Editor-in-Chief Steve Shorrock has done it again. He has put together another issue with a very topical subject – Handling Surprises. The last two and a half years were full of surprises from the pandemic to war, from the oil and energy crisis to aviation coming back to 2019 levels faster than expected. And when we talk about surprises and unexpected events, we inevitably think of resilience. Others call it antifragility. Whatever it is, how do we learn from surprises and embed the lessons in our capability to cope with them?

With the unexpected becoming a larger chunk of everyday life, it isn't surprising that we find ourselves interested in resilience and coping. A few events have stood out in my safety career and I have looked to learn from these with my EUROCONTROL team: The Cerro Grande wildland fire, Hurricane Katrina, the Asian tsunami, the Enron scandal, the Columbia space shuttle disaster, 9/11, the London bombings, the Santiago de Compostela train disaster, COVID19. These have all tested the stability of many organisations. But most organisations experience frequent unexpected events on a much smaller scale. These dynamic and uncertain times raise the questions of how and why some individuals and hence their organisations are much more capable than others of maintaining safe operations in the face of drastic change, and return stronger to tackle future challenges.

"We were not prepared in terms of our capabilities, human or technical."

I am an avid reader of Nicholas Nassim Taleb's books about high impact low-probability events (*Black Swan*, *Antifragile*, *Fooled by Randomness*, *The Bed of Procrustes* and *Skin in the Game*). The black swan is a metaphor that describes an event that comes as a surprise, has a major effect, and is often inappropriately rationalised after the fact with the benefit of hindsight.

Let's rewind back to the 90s when I started in air traffic control. I had a couple of surprises that probably affected how I view surprises now. The first surprise of my career was on 17 June 1993. I had only a couple of years in OPS and witnessed an exponential increase of air traffic in Bucharest FIR. Events in a neighbouring country led commercial flights over the Romanian skies (following an unfamiliar axis). It was predicted that movements would continue to surge in the next years. We were not prepared in terms of our capabilities, human or technical.

Together with my colleague Razvan Bucuroiu, we were tasked to add 300 en route ATCOs in one year without jeopardising safety. What helped us was that we recognised that we did not know immediately how to do it. Bregman (2011) outlines three steps to handling the unexpected: 1) Stop the boat; 2) Assess your actual options; 3) Sail. It turned out that this is exactly what we did. We paused and did not allow ourselves to be pushed into an immediate decision. We did not have time to waste wishing that the situation would be different. After an assessment with a diverse team, including our Director at the time, we assessed our options, made a decision, and stuck to it. We decided to recruit aerospace engineers that did not need an intro on how an aircraft fly, but they needed hands on exposure in the simulator and in the OPS room. Almost 30 years later those 300 ATCOs remain the pillars of ROMATSA and they approach their retirement.

Fast forward to early 1999 and I faced another surprise of a different nature. During the Kosovo war, for the first time, we were accommodating military and civil operations safely and allowing over 130 commercial movements every two hours in a reduced airspace (the rest of it was segregated for NATO military operations). Again, we were not prepared but with a highly educated workforce (ATCOs with Master degrees, even some PhDs) we were able to compensate with a capability to improvise. During one night, this capability backfired. The FDP was designed by us and was using a 'state of the art' (at that time) database allowing a maximum of nine points in Bucharest FIRs, out of which two were reserved for entry and exit from the FIR. I don't know

how, but we entered 10 points and we crashed it. We followed the same three-step process (mapped in the earlier surprise).

This time I was in the boat with Head of Software Development (Razvan Margauan). First, we knew somehow that we had to "stop the boat" and think. It was at the start of the night, so we had time. Without realising at the time, we followed the advice of Paul Petzoldt, the mountaineer and founder of the National Outdoor Leadership School: *"The first thing you should do in an emergency situation - once you know things safe - is stop and smoke a cigarette."* (Of course, it doesn't have to involve smoking, but stopping, removing yourself from the chaos, and reflecting.) We got up, took a walk, and went for smoking break to assess the situation.

Again, the second step is to "assess your actual options", and this is what we did. We decided what we wanted to happen and considered the options. This had to fit the reality of what was happening, not what we wished was happening.

"Success in the past is not a guarantee of the future."

Then we moved to the third step: "sail". Based on the assessment, we made the decision to call a huge number of colleagues from home. We turned all the land lines red, and brought in as many people as we could to start writing paper strips and prepare for the next day. And we stuck to it. While some were trying to diagnose and restart the FDP, the rest started operations manually for the full next day. The point here is that even if the decision isn't ideal, even if it's not giving you everything you hoped for originally, accept that it's the best under the circumstances to move forward. By midday the following day, the FDP restarted and we could sync all the data. We were back in business but still used the manually prepared strips all morning.

I am sure all of you have your own stories. My advice is to read *HindSight 34* and try to bring the knowledge of the great articles of this edition to your day-to-day activities. After the last page of this edition just ask yourself, in the words of Professor David Woods – is my organisation prepared to be surprised? Success in the past is not a guarantee of the future – navigating safely through COVID19 is not a proof that you will survive the next crisis…or surprise. As Intel's former CEO Andy Grove said, *"Bad companies are destroyed by crisis, good companies survive them, great companies are improved by them."*

Tony Licu is Head of the Safety Unit within the Network Manager Directorate of EUROCONTROL. He leads the deployment of safety management and human factors programmes of EUROCONTROL. He has extensive ATC operational and engineering background, and holds a Master degree in Avionics.

Reference

Bregman, P. (2011, July 06). Three steps to handling the unexpected. *Harvard Business Review*. https://hbr.org/2011/07/three-steps-to-handling-the-un

SKYclips

SKYclips are a growing collection of short animations of around two minutes duration which focus on a single safety topic in aviation. Created by the industry for the industry, they contain important messages to pilots and air traffic controllers with tools for safe operations.

There are SKYclips on the following topics

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- Airside driving
- Airspace infringement
- Airspace infringement and aeronautical information
- Birdstrike (new)
- Callsign confusion
- Changing departure runway while taxiing
- Changing runways
- Conditional clearance
- Controller blind spot
- CPDLC
- Downburst (new)
- Emergency frequency
- En-route wake turbulence
- Helicopter somatogravic illusions
- Immediate departure
- In-flight fire
- Landing without ATC clearance
- Level busts
- Low level go around
- Low visibility takeoff
- Mountain waves
- Pilot fatigue
- Readback-hearback
- Reduced TORA (new)
- Runway occupied medium term
- Sensory illusions
- Separation of arrival and departure during circling approach (new)
- Shortcuts and unstable approaches
- Speed control for final approach
- Startle effect
- Stopbars
- TCAS - Always follow the RA
- TCAS RA high vertical rate
- TCAS RA not followed
- Unexpected traffic in the sector
- Workload management

Each SKYclip is developed by aviation professionals from a variety of operational, technical, and safety backgrounds.

Birdstrike

Downburst

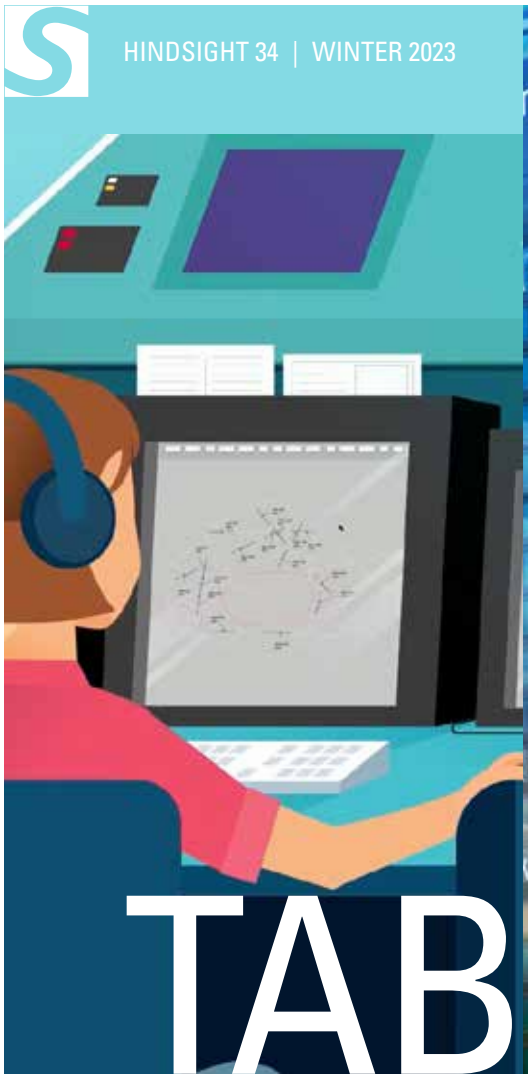

Helicopter somatogravic illusions

Reduced TORA

Separation of arrival and departure during circling approach


Changing departure runway while taxiing

Find the SKYclips on SKYbrary at https://skybrary.aero/tutorials/skyclips



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CONTACT US

HindSight is a magazine on human and organisational performance in air traffic management and related sectors. The success of this publication depends on you. Please tell us what you think, and spread the word to your colleagues. And please share your experiences with us. We would especially like to hear from front-line personnel (the main readership) with a talent for writing engaging articles.

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Georgi Peev
Director General BULATSA

In recent years, the process of handling surprises has become part of the 'new normal' for the aviation industry. In very little time, we all faced unprecedented events, from a widespread and prolonged global health crisis to large-scale geopolitical conflicts and associated skyrocketing fuel prices, and the devastating war in Ukraine. And these are only some of the disruptive events that have significantly affected our industry.

Back in the day as an air traffic controller, I was trained extensively to act quickly and decisively in abnormal situations. Air traffic controllers know that they must deal with a problem no matter how complex and unexpected it is, and how many unknown factors there might be. It is in their core and part of their professional mentality, in which they take pride. They know that they will not abandon their duty regardless of the challenges they are facing.

Speaking from such experience, I was confronted with several abnormal, even unprecedented events during my years at different positions in BULATSA. I recalled the instructor's mantra: "*Be prepared for worse than you expect*." I repeated this lesson to my air traffic controller trainees myself as an instructor. This lesson was deeply embedded during my years in the OPS room and I took it with me. As time passes, I have realised that this has proven very useful to keep me one step ahead of every situation.

When it comes to handling surprises, there is no silver bullet, but many actions can be planned in advance. And a strong team of professionals helps to prepare for the next unexpected – perhaps unimaginable – event. Such a team has mutual trust in each other's abilities and acts as one when challenged with the next surprise hiding around the corner.

Again, my years of experience have taught me to accept that the only constant thing in life is change. The ability to adapt as quickly as possible to change builds the resilience needed to bounce back even from situations which at first appeared 'all doom and gloom'. Being comfortable is a good feeling but it does not always bring us closer to our goals. We sometimes gain more by learning how to feel comfortable with being uncomfortable.

The unexpected crises and challenges that we face are also drivers for embracing new technology. The technology of today is changing so rapidly that in ATM we are challenged to integrate new hardware and software safely. This has been our focus during the last decade. Our ATM systems now include workload analysis and prediction tools, ATCO-Pilot communication via data link, Mode S data downlink, satellite-based surveillance and many other tools which are gradually changing the workplace. However, the core remains the same – nothing beats the importance of the strong team spirit, human collaboration, expertise and open communication. This will remain the winning strategy in dealing with surprises at the sharp end in the years to come.

Georgi has a master's degree in engineering from the Technical University – Sofia specialising "Operation of electronic aviation equipment (Air Traffic Controller)". He became a professional air traffic controller in 2000 and has extensive experience in the field of civil aviation and air traffic management. In 2014 he was appointed Director General of BULATSA and participates in the governing bodies of a number of international organisations in the field of civil aviation.

Steven Shorrock
Editor in Chief of *HindSight*

"What we experience as 'fast surprises' may develop slowly behind the curtain, sometimes over many years, and peep out to become observable quickly, perhaps in seconds."

SURPRISES, FAST AND SLOW:

PREPARING FOR THE LIMITS OF WORK-AS-IMAGINED

In safety-critical industries, surprises are rarely welcome. Aside from unexpected events we perceive as pleasant, like receiving a birthday cake, a thank-you note, or even a day when everything works as expected, surprises are not good things. The unwanted surprises that we may encounter, and how they are handled, differ depending on who we are and where we are in the system, whether in the control room, flight deck, surgical theatre, or boardroom.

Fast Surprises

In operational roles, surprises tend to be experienced over a short period. The most common variety seems to have 'fast shoots' and 'fast roots', developing quickly, then emerging and becoming detectable quickly, perhaps over seconds or minutes. There is often a rapid change in the context, or a mismatch between expectation (or imagination) and reality, or both. For a pilot or controller, it could be an in-flight medical emergency. For a clinician, it could be a rapidly deteriorating emergency patient.

Such surprises evolve with rapid changes to the operational situation and the associated contexts, such as physical (e.g., aircraft behaviour), environmental (e.g., wind shear; thunderstorm), technological (e.g., automation surprises), informational (e.g., display parameters), temporal (e.g., time pressure, exponential effects), and social (e.g., others' unexpected actions).

These are operational surprises, dealt with operationally. A fast response is usually necessary, which requires training to recognise the signs and react. One well-established model is known as recognition-primed decision-making (RPDM) and applies when people need to make fast and effective decisions in complex situations. What happens is a blend of intuition (recognition) and mental simulation, typically considering responses serially for the first 'good enough' option that fits the developing contexts.

But what we experience as 'fast surprises' may develop slowly behind the curtain, sometimes over many years, and peep out to become observable quickly, perhaps in seconds ('fast shoots, slow roots'). Such surprises may be very difficult to handle because of the interconnected changes in the contexts of work that originate further back in time and space. These may be political (e.g., performance targets), legal and regulatory (e.g., prescriptive limits), organisational (e.g., training cuts; staff shortages), technological (e.g., software updates; new automation), and procedural (e.g., out-of-date procedures; conflicting policies).

Again, a fast response will typically be necessary, but it is more difficult because decision-making faces formidable constraints. Other constraints may be invisible as people become habituated to how things are. Whatever solution is applied in the moment will not fix the contextual sources of the problem, so more surprises are likely.

For fast surprises, Captain Ed Pooley noted in *HindSight 21* that *"the 'system' in both the flight deck and in the control room must be able to cope with the particular case of a (very) sudden and (entirely) unexpected transition to high workload ... Recovery – or at least containment – before overload is reached becomes the aim."* He noted that many situations are covered by procedures, in training and in operations. Others are more unique and demand *ad hoc* decision-making. To be effective, surprising simulated scenarios must be hidden so that they are indeed surprising, and *"a huge library of representative training scenarios must be developed so that the surprise they provide is as near to real as possible."* But not every scenario can be anticipated. Training must therefore assess fundamental competence in coping with surprises.

Talking about firefighting incident command, Sabrina Hatton-Cohen said in *HindSight 31* that simulations *"can be incredibly powerful learning tools because you can go through the 'what if' scenarios and run through a number of different variations of each scenario."* Her team found that well-designed command training simulations elicited similar decision-making processes to those observed in real life.

In a healthcare context, surgeon Euan Green noted in *HindSight 33* that *"Given the rarity of true surgical emergencies … it is important to continue to run these drills at intervals; while surgeons stay in their roles for many years, nursing and support teams can change regularly."*

Fundamental competencies proved important in the landing of QF32 (see *HindSight 29*). Four minutes after take-off, engine number two exploded without warning, followed by a second explosion, with 21 out of 22 aircraft systems compromised. Within a few minutes, there were over 100 ECAM checklists. Competency was often in the spotlight when I interviewed Captain Richard de Crespigny. Richard said that controllability checks were critical to the safe landing of QF32. He explained that, while this procedure is habitual for military aviators, it wasn't documented in any Airbus manual or the airline's manual until after QF32. He learned about them in the Air Force: *"It's normal Air Force procedure that if your aircraft has a mid-air collision or has taken damage from an attack, and flight controls are affected, then you must determine the best configuration and the minimum speed that you need to land."* Similarly, during landing, he used a technique that is *"not practised in any simulator."*

Slow Surprises

Other surprises develop slowly, and become observable slowly, without the same kind of urgency for response as the kinds described above. Both the 'roots' and 'shoots' may grow over weeks, months or years, and recognising, understanding and handling them can take a long time. They are still surprises because reality and our expectation are mismatched, but this mismatch is revealed or accepted slowly.

The underlying contexts are similar to the 'slow roots' variety above (societal, political, legal and regulatory, organisational, technological, procedural, etc.). There are likely to be cultural implications, as shared assumptions about the world change and develop over years. This cultural context, combined with the slow unfolding of the surprise, creates even more constraints on handling surprises. The reality of the situation may be harder (for some groups, at least) to accept.

From a flight deck perspective, Kathy Abbott explained in *HindSight 34* that there can be crucial differences between claims and operational reality when it comes to new technology. *"We've seen so many cases where there are side effects that were not expected."* She explained that the problem for people in technical roles is not a lack of willingness to consider unintended consequences, but lack of knowledge how to do it, or who can help. Predicting so-called 'emergent properties' of new technology is notoriously difficult, and expertise in individual technical systems or even technical system architecture probably won't be sufficient.

Kathy Abbot indicated an issue with slow surprises: they can be surprising to some but not others. *"I personally have heard design engineers say that they don't understand why it's a problem, that it works exactly as designed."* But from an operational point of view, there is a surprise because their expectations are not met.

In *HindSight 25*, Suzette Woodward told the story of the World Health Organisation (WHO) surgical checklist, designed in 2006. The checklist includes things to check off prior to surgery to ensure 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. ... 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."*

"We tend to overestimate the degree to which future work-as-done will follow our designs and plans."

This brings us to a key point for slow surprises: We tend to overestimate the degree to which future work-as-done will follow our designs and plans. On the one hand, this is because of the nature of the world, and the ever-changing contexts of work. On the other hand, it because of the nature of us, and the lethal human cocktail of ignorance, fantasy, denial and overconfidence. Not only do our plans not always work, but our designs and plans often bring more problems. Even small changes to procedures can have disproportionately large effects. And so we experience unwelcome surprises. As work becomes more complex, unintended consequences become the thorn in the side of imagination.

For these kinds of surprises, it is rare to find procedures and training on how to detect and handle them. But in *HindSight 27*, Anders Ellerstrand reported on requirements to improve resilience, and the potential to respond, monitor, learn and anticipate. In short, competency is needed, from front-line operators to senior managers, to respond, monitor, anticipate and learn from unexpected events. It should be known who has what expertise and authority to handle a given part of a situation. Expertise is not the only requirement (teamwork is critical), but almost all capability to handle surprises is dependent upon it.

Investment in expertise, however, is often a victim of cost-cutting in lean times. It is a mistake repeated so often that it seems that organisations have lost the ability to learn even from this mistake. Since surprises will continue, and almost none will be pleasant, the question is whether we will ensure that we continue to commit to our own expertise, and make sure our organisations and professional associations support us and the wider system.

ON BEING PREPARED TO BE SURPRISED:
20 KEY INSIGHTS FROM DAVID WOODS

Over the last four decades, **Professor David Woods** has studied and advised government agencies, companies and accident investigation boards on surprises and unexpected events in industries including aviation, space exploration, healthcare, and software engineering. **Steven Shorrock** picks out 20 key insights from a conversation on being prepared to be surprised.

1. The process of surprise follows a familiar pattern

"Beginning with an initial signal, the process flows across a series of transitions from a physiological response, to a sensory response, to a more interpretive perceptual response, and an emotional response, to a more cognitive then cooperative activity. The whole transition needs to go smoothly and coherently across those stages. At some point we realise, '*This doesn't fit!*' This marks the transition to a sense of surprise: '*I'm in a different world. I am now in abnormal operations. There are unexpected, anomalous, and discordant indications to resolve.*' People can get thrown into a kind of incoherence along the way. You're thrown off track and it's hard to get back on track given the time pressure. That's when the response breaks down."

2. We confound surprise, the unexpected, and startle

"In the flight deck, the word 'startle' sometimes gets misused. Startle refers to a physiological response to threatening, sharp onset signals – a sudden dramatic shift. Startle delays response and can disrupt initial processes to monitor or scan, recognise, understand the event and what it means for response. But mitigating that is difficult. Startle is controllable in a very limited sense and in terms of very specific kinds of things, which

don't work for everybody. There are significant individual differences."

3. Surprises can be situational or fundamental

"Surprise is about the unexpected. Surprises challenge our model of how the world works or should work. When surprised, we have to make sense of what doesn't fit. This can take the form of a situational surprise – how to minimise the implications of the surprise (just a little fine-tuning to restore the model). Alternatively, the response can take the form of a fundamental surprise where people engage in processes of revision and re-conceptualisation."

4. The only certainty is uncertainty

"Sometimes, the only thing I know for sure is that there's high uncertainty. But this can be a definite signal telling me I have to get more information, and I have to create the possibility for swift action once I understand what's going on. The big question is, are you prepared to revise as more evidence comes in? You may have to back up and re-examine what's really going on in terms of what you can see and hear and feel. This is where the classic questions arise during automation surprises: '*What's it doing? Why is it doing that? What is it going to do next?*'"

5. The transition to scan after surprise is critical

"It is important to help support people to get back into a disciplined scan in the computerised cockpit. In the old analogue cockpit, experienced pilots had a very disciplined scan to make sure they were getting all the information relevant to understanding a potentially abnormal situation."

6. Simulator responses can be very different to real world responses

"Even though it's full scope and high fidelity, pilots know they're in a simulator, and the ability to respond to an abnormal situation is always faster than in the real world. So, you should always design and train with that in mind. It's a different world and a different tempo in the air. A five to 10-second response in the simulator might even double in the real world."

7. Therapeutic responses give crucial diagnostic information

"Actions can help you figure out what's going on (the unexpected part), while potentially helping to handle the situation (the abnormal part). You don't have to know immediately why the engine is losing power, but you do need to stabilise flight as power drops. The actions to respond are corrective, or therapeutic, as they help manage the situation. The very same actions also provide diagnostic feedback. How the aircraft and systems respond to actions reveals more about what is wrong and what does or does not explain the situation. Plus, what produces the surprise can lead to unexpected actions by automated systems. Tracking what the automation is doing or not doing can get difficult under time pressure. The classic view of a strict linear sequence from assessing information, building a diagnosis, then acting, doesn't capture how these are intertwined during surprise events."

8. Sudden collapse can happen at the system level

"In socio-technical systems, the processes that respond to surprise and coordinate responses across subsystems can degrade. We normally compensate, but we can run out of the capacity to continue to handle a growing problem or a deteriorating situation. As things get worse, the ability to continue to respond diminishes, leading to a sudden collapse in performance. In control systems this is the general problem of saturation. It is also how brittle systems fail. In trying to keep up with threats, the system needs the capacity to stretch and adapt to handle the effects of surprise and reduce the risk of brittleness. This is a special capability that experienced expert people provide."

9. The way that we think about probability misleads us

"Classically, people think of surprise in a probability sense. Surprising events are relatively rare events, in the tails of the distribution. The problem is, in real world probability distributions, the tails are bigger than we think. In other words, the probability of low frequency events as a class is much higher. It's not that surprise is rare. Surprise is always happening at the boundaries. After the Columbia accident, I said to Congress that, paradoxically, extra investment in safety is most needed when it's least affordable. You need to be prepared to be surprised and prepared to adapt."

10. It is necessary to focus on reliability, robustness and resilience

"You have to prepare for all three because they're so different. You can't know all of the things that will go wrong, and you don't have enough resources to prepare for all contingencies. Plus, the world will change. We rely on the pilot to understand and act constructively in a situation that doesn't fit what we thought we were prepared to handle."

11. Everything operates under limits

"It's not that designers are bad at their jobs. It's that everything operates under limits. Engineering design operates under limits. The machines that result have limits. People operate under limits.

And the world keeps changing. Those changes will present surprises that highlight the limits of our decisions. What reasonable trade-offs will need to be readjusted as we appreciate the new information in surprise events? This was missing in the run up to the Columbia accident."

12. The act of compensating successfully hides what is difficult

"There is a law called known as the fluency law. It means you adapt successfully most of the time. As a result, you and others don't see the difficulty, or the trade-offs, or the dilemmas that arise, but are handled regularly. There is a source of strength in people that is hard to appreciate even though it is called into action regularly to handle the stream of small surprises in all systems with limits. Often, no one noticed that they were adapting to recover, demonstrating resilient performance. And we didn't notice that because people – in the end – handled it successfully, leaving the surprise and adaptation partially invisible."

13. We have to be prepared to be surprised, even by our own mitigations

"So, when we say, *'how to be prepared to be surprised?'*, we mean that your model of the world does not match the world you're really in. What we thought of as risk mitigation shifted trade-offs and exposed us to other risks. So rather than always getting better and the probability of something bad happening always going down, vulnerabilities actually change. We are more effective in some ways, but the system changes and we get surprises."

14. Adaptive capacity is future-oriented

"We have to think about adaptive capacity as a potential to act in the future when things are different than planned. We know that we have finite resources, and we have to make compromises and trade-offs even as we pursue reliability and robustness. We know that challenges will arise, but the challenges will arrive in unfamiliar forms. Things work as well as they do because there are hidden sources of resilient performance to handle the regular occurrence of surprising events."

15. We need to understand how people handle surprises

"To some degree, we start to reveal fluency by getting people to share more information about how they do things. What makes you as an experienced controller different from a newer controller? If you're supervising a relatively inexperienced person, what do you bring to handling a situation that's different? As you recognise that a situation may become more difficult to handle, how do you make small adjustments in advance?"

16. People provide the ability to stretch

"Management must first understand that people adapt to handle surprises and other difficult situations. People

provide an ability to stretch at the boundaries. It doesn't have to be people, but it turns out it is almost always people. Pilots, controllers, engineers and other actors provide a source of resilient performance; they adapt to make the system work. And we count on that."

17. Experience matters

"It is important to appreciate that there's great value in experience. This requires long-term planning to retain this critical asset for resilient performance. You need a balanced portfolio with a long-term approach to sustain the base and mix of experience."

18. You can't take past safe performance for granted

"In ultra-safe systems, there is a risk of taking past safe performance for granted. But again, a record of reliability does not guarantee future robustness or resilient performance. If you rely on a record of past reliability, you'll have less robustness than you think, and you'll cut out some of the critical human sources of resilient performance that help you handle surprises and other difficult situations."

19. The world will throw more surprises at us

"Today the world is going through transitions and changes that reverberate in unusual ways or ways that we don't expect. The world will continue to change in ways that will be surprising in terms of their tempo and impact."

20. Managers need to be agile

"By the time you put in your traditional change programme, the world has moved on twice! You need to be more highly adaptive in a turbulent world and that requires management to rethink things. In the new world we're living in, management has to learn to be agile. Management cannot be slow and stale. You must develop the potential to adapt in a changing world."

Read the full interview with David Woods in the Online Supplement to HindSight 34 on SKYbrary at https://skybrary.aero/articles/hindsight-34

Professor David Woods has worked to improve systems safety in high-risk complex settings for 40 years. These include studies of human coordination with automated and intelligent systems and accident investigations in aviation, nuclear power, critical care medicine, crisis response, military operations, and space operations. The results of this work on how complex human-machine systems succeed and sometimes fail has been cited over 33,000 times and synthesised in several books. He is Past-President of the Human Factors and Ergonomics Society and the Resilience Engineering Association. He has received several awards and has provided advice to many US and international government agencies, companies, research councils, task forces, and accident investigation boards.

THE CHICAGO FIRE

A fire in the Chicago air route traffic control center destroyed telecommunications infrastructure, damaging essential air-to-ground communications and flight planning capability. **Tim Arel,** Chief Operating Officer of the FAA's Air Traffic Organization, explains what happened, and what was learned.

We've all learned that we should plan and drill or prepare for workplace contingencies, but as much as we try, we can't imagine every circumstance that will come our way. A key lesson for the Federal Aviation Administration (FAA) over the years has been our focus on developing the right foundations to allow us to be agile enough to rapidly respond to foreseeable events, and knowing how to pivot when an unpredictable event occurs.

We have 580 staffed air traffic control facilities and around 74,000 pieces of equipment in the US National Airspace System (NAS). And like many other ANSPs, we have planned for and experienced system and facility outages due to equipment failures and natural disasters. Our goal, of course, is to prevent disruptions in the NAS, and we have established contingency plans for these commonly recurring events and every facility has a scalable plan for dealing with them.

We routinely plan for natural disasters such as hurricanes and wildfires and we include those plans as part of our annual refresher courses. This allows us to review checklists as well as employ threat reduction and risk analysis tools. When we see the condition approaching, we establish a joint crisis action team or JCAT in our national command center. This is a small cell that can vary in size depending on the needs of the event. Typically, a JCAT will be formed with FAA representatives from key operational service units, operational support service units, and experts from our command center, dedicated to the event.

We also pre-position people, equipment and supplies in strategic areas as close to the event as possible where we can respond as soon as it's safe to do so. That includes pre-positioning our agency's aircraft along with teams of technicians and rapid 'go teams' ready to deploy. The point is that we plan and respond as an organization with all of our operational support elements coordinating in real time, led through those conversations at that JCAT.

"What was most impressive is the amount of work that our technical operations team had to do."

One large-scale event quickly escalated beyond the scope of our normal contingency plans: The Chicago center fire. In September 2014, a contract employee deliberately set fire in a critical equipment area of our Chicago air route traffic control center. The fire destroyed our telecommunications infrastructure, essential to all air traffic control voice and data communications, at a central communications equipment node in the building even though it had redundant pass on the way into the building. This took out our essential air-to-ground communications capability as well as our ability to process flight plans at one of the busiest centers in the country. We initially stopped all traffic from transiting Chicago Center's airspace but quickly transferred this high-altitude traffic responsibility to adjoining centers. These adjacent centers did a fantastic job overcoming the limitations of their surveillance and communications capability. Several of our radar approach control facilities pitched in and provided services to aircraft at lower altitudes.

Nearly 200 of our Chicago Center controllers were dispatched after a couple of days to the surrounding facilities to provide advice and support in those areas that were now working Chicago's traffic. Air traffic controllers are certified to work specific airspace.

In this situation controllers who were not certified in Chicago airspace worked traffic alongside Chicago controllers who were certified and knew the airspace. As a result, we were able to operate near-normal levels at Chicago's O'Hare and Midway airports during the 17-day outage.

What was most impressive is the amount of work that our technical operations team (Tech Ops) had to do to reroute surveillance and communications capabilities to those surrounding facilities. As if this weren't remarkable enough, Tech Ops simultaneously restored 20 racks of equipment, 835 telecommunications circuits, and more than ten miles of cable to reroute traffic communication and data to adjacent facilities while restoring service to the damaged Chicago Center facility. Still, passengers were significantly inconvenienced, and the airlines incurred incredible cost due to delays that had to be endured until we resumed service in Chicago.

The Chicago fire and the associated insider threat got our attention and made us shift from not only a risk management and contingency planning perspective, but to focus on system resiliency as well. We have a robust national airspace system and it could handle temporary deviations, but we learned we needed to measure and address our ability to rebound from surprise events that fall outside of design parameters. We shifted our focus to making buildings and systems more resilient with additional layers of redundancy to prevent future events.

We also learned, and we explained to our Congressional oversight committees, that we could not afford to have a spare air traffic control center standing by with extra controllers certified on every piece of airspace throughout our system. As for addressing the human element of this contingency equation, we added enhanced security measures and additional background checks as added threat reduction measures.

Overall, we have learned to design, monitor and respond from a system perspective. Despite our best efforts, we cannot anticipate every unique situation, but by empowering our professionals to be innovative and flexible, while meeting the intent of our contingency plans, following the tenets of our safety management system in collaborating, we have matured into a more resilient organization.

Timothy L. Arel is Chief Operating Officer of the FAA's Air Traffic Organization. Throughout his 33-year career with the FAA, Mr. Arel has developed expertise in airspace security, air traffic safety, resource management and labor relations. He is a member of the CANSO Executive Committee, which serves as the organization's board of directors. Tim is a veteran of the U.S. Air Force and has a background in public safety, having worked as an emergency medical technician, firefighter, 911 operator and police officer.

"We learned we needed to measure and address our ability to rebound from surprise events that fall outside of design parameters."

A DAY WHEN (ALMOST) NOTHING HAPPENED: A PERSONAL PERSPECTIVE

What we would do in the event of a major surprise is not always known to us until it happens. **Tom Laursen** gives an example of how operational and technical staff coped with a total loss of flight data.

As an air traffic controller, I experienced a number of surprises throughout my career. Thinking back, I can put them into two categories: the ones that happen every day, that are hardly noticed by anyone, and the rare events that sometimes cost sleepless nights, and that leave a trace in your memory. The everyday surprises are hardly noticed because the air traffic control system is well calibrated to respond to them. They range from adjusting to unexpected changes due to weather (e.g., wind and clouds), to different cultures and accents, and different airline policies (e.g., fuel policies). These changes or surprises are dealt with smoothly and without any disturbances of the safe and orderly flow of air traffic.

The surprises that have left a trace in my mind are rare and usually had an impact on the orderly and safe flow of traffic. Just to mention a couple, in the beginning of my career, when we worked with very little safety net support, I forgot an aircraft and climbed another one through its level. How the two aircraft passed each other is still a mystery to me. I never reported the incident, because I feared the consequences. Another type of event that left a trace were situations that involved military aircraft. The difference in nature between civil and military operations is significant and leads to many situations that evolve in high-tempo and lead to close encounters.

I also worked in skyguide when the Überlingen accident happened. The accident gave months of sleepless nights and left a significant mark for life.

In this article, I will focus on an event that happened not so long ago in a control centre in Europe. It was an incident that was, like many technical glitches that I have experienced, not supposed to be possible. Because of what I have experienced as an ATCO over a 33-year career, I am suspicious when decision makers and companies

promise that breakdowns of new technical equipment will only happen once every 100 years. If this were true, there will be few or no future technical surprises in the European aviation system.

"We need to study how we manage these events, mainly to understand why we are good at responding, but also because it's those events where the ATM system is pushed towards its limits."

It was also an event where the involved operators were very surprised and worked hard to maintain a safe and orderly flow of traffic, but this effort was not visible, since the orderly flow of traffic was hardly affected. These events are fortunately rare, but not as rare as many people think. The reason for that (in my view) misconception, is that many of these events do not show up in any incident statistics, although they are the events that I think we should pay most attention to. We need to study how we manage these events, mainly to understand why we are good at responding, but also because it's those events where the ATM system is pushed towards its limits.

The Event

During an afternoon shift in an air traffic control centre, everything was as usual with only little traffic. The centre makes use of a computerised air traffic control and management solution with a distributed computing architecture that integrates geographically dispersed air traffic control units in a Flight Information Region (FIR) into a single coherent air traffic control system. At about 13:10, the screens at the operator working positions suddenly turned 'black', meaning that all tracks of the aircraft disappeared. After a few seconds the tracks reappeared, but without the labels that contained information about the call-sign, route, destination, type of aircraft, speed, etc.

The air traffic controllers (ATCOs) did not know what had happened, except that some kind of system breakdown had occurred. They soon realised that there was no flight plan information in the system, which meant that the ATCOs were unable to correlate the tracks. The Mode S downlink provided information about call-sign and flight level of the aircraft that were Mode S equipped. (Mode S is a Secondary Surveillance Radar process that allows selective interrogation of aircraft according to a unique 24-bit address assigned to each aircraft. It had recently been introduced in the control centre.) The information was, however, not displayed as it normally would be and the ATCOs decided against relying on Mode S as it's not mandatory for all aircraft.

The ATCOs began to use Modes S information to identify aircraft and manually to make an abbreviated flight plan as a substitute for what should have been provided automatically. All aircraft on the frequency were asked about their destination and aircraft type. Furthermore, all adjacent centres were advised to perform manual radar hand-over (a function that works seamlessly under normal operations), just as departures out of domestic airports were advised to stay on the ground to lighten the traffic load. All spare personnel were called and a procedure to find information and coordinate with adjacent positions and centres was soon established. This happened within a very short time – approximately five to eight minutes after the technical failure. When it was felt that an acceptable level of service again could be provided, departures from domestic airports were released.

After the Event

The ATCOs began to reflect on what had happened and discuss what they were actually allowed or advised to do according to existing rules and guidelines. The control centre has a backup system with its own screen next to the main controller screen. The backup system is to be used to evacuate the airspace in situations like the one that happened, when all information about the aircraft has been lost. The ATCOs, however, did not do that because the situation quickly had been brought under control.

While the ATCOs had found a way to handle the situation, the technical department had simultaneously analysed the breakdown and identified the technical source of the problem. After about 30 minutes the computerised control system was therefore up and running again.

Unfortunately, two more breakdowns took place because of the same technical problem. In both cases the situation was quickly recognised as a repetition of what had happened earlier, and the same recovery actions were carried out. It was decided to revert to the previous software release during the night, when traffic density was low.

My Take-away

Erik Hollnagel signs his emails with this quote: *"The difference between what you can imagine and what can happen, is larger than you can imagine."* Based on my experience, this quote is very useful for the organisation and design of today's aviation system. We are quite good at predicting and we spend a lot of resources predicting what can happen. But we will never be able to fully predict and anticipate all scenarios. Therefore, we have spent decades designing the aviation system to be well prepared through highly qualified experts, procedures, airspace design, technical support, and many other measures. These enable operators to respond to many situations, including surprises.

Because we are good at responding to many challenges, we often forget why we are good at responding to the challenges that sometimes come as major surprises. In my view, the reason why we are good at it is because we have a system that balances formally designed procedures (thorough preparation) with the ability to respond in real-time to the difference that we can't imagine, as Erik puts it. The importance of the ability to respond is becoming more accepted and incorporated in our thinking.

But we still have a long way to go before the thinking is used and incorporated

in how we organise and design the aviation system. Too many, especially decision makers, still believe that the designers of today's aviation system can predict all situations and therefore the goal of many bigger projects are to get rid of, or minimise, the presence of resources that can respond in real-time – people. This is, in my view, the wrong way to go. We need to design systems that can use the combined strengths of the human and the technology to be able to maintain the ability to respond, as well as was done in this example, to surprises.

Reference

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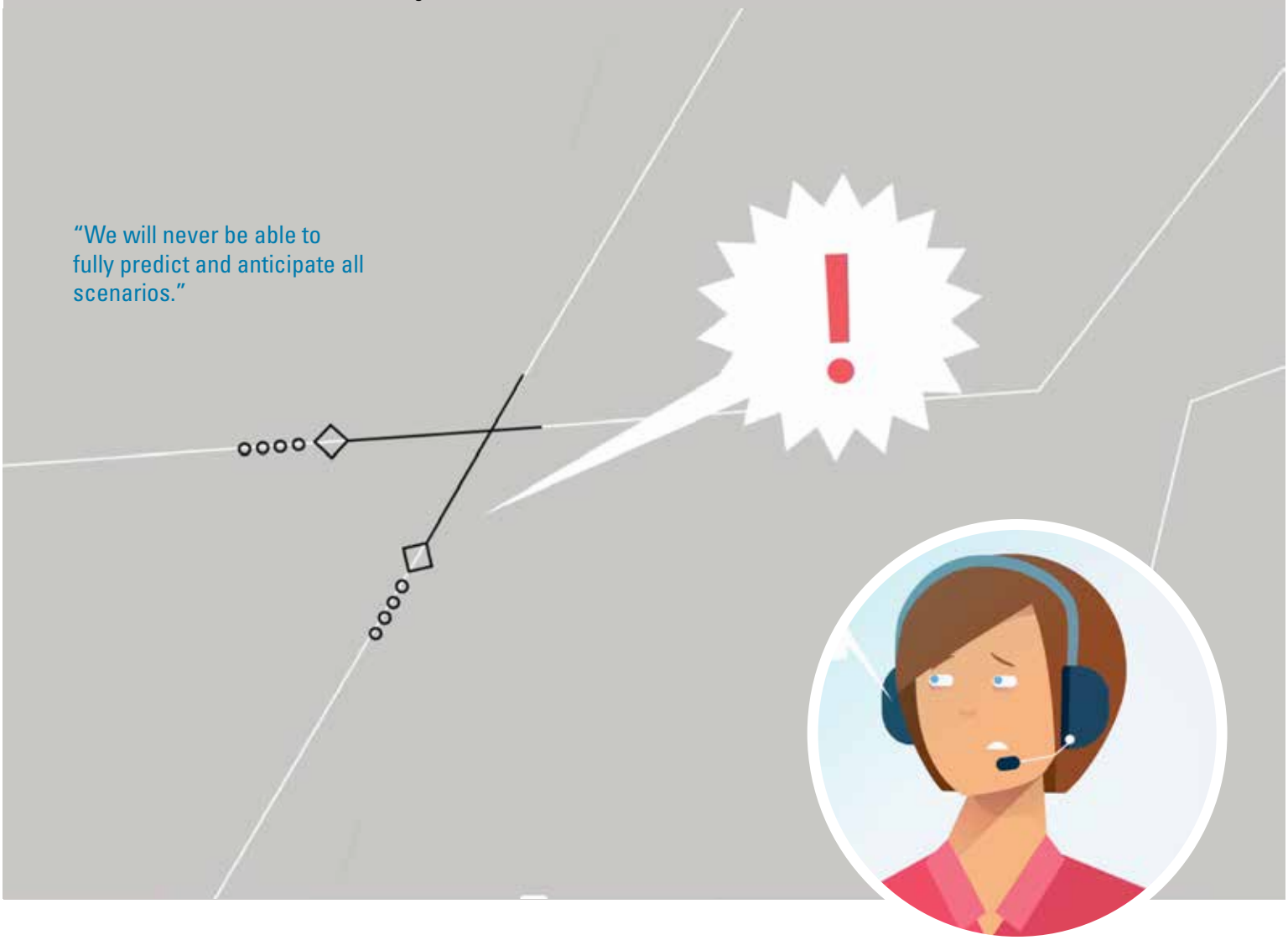
"We will never be able to fully predict and anticipate all scenarios."



"IF WHAT YOU WRITE IS CORRECT, WE MUST SHUT DOWN OUR TOWER"

In stressful situations, we often react in a way that we would not imagine. **Sebastian Daeunert** provides a case study of what can happen when we are suddenly confronted with several challenging and stressful tasks.

KEY POINTS

- **Differences in understanding can create surprises.**
- **Stress affects the way that we react to situations.**
- **We need to improve the environment so that we can manage stress during sudden high workload periods.**

"If what you write is correct, we must shut down our tower." This is what my boss said when he had read my investigation report, only to add: *"But what you write is very important. I need you to come with me to explain why we are doing this to my superiors, so they understand what we are doing here."* I liked the way he used the word "we". In my view he was an excellent leader.

What had happened? I had just finished a Human Factors course by Sidney Dekker. Incident reports prior to that used to finish with the sentence *"The controller recognised his mistake, apologised and promised to never do it again"*. My investigation report was an expedition into uncharted territory. This case is not recent, as you may have realised by now. And it's not about developing a new approach to investigation.

We are back in 2011, Frankfurt International had three runways: RWY 18 for departures to the southerly directions, RWY 25 L/R for arrivals and departures to the north. One controller worked RWY 25 L/R, the other RWY 18. Additionally, we had a coordinator, start-up controller, flight data assistant (sometimes two), and a supervisor, in the small OPS room of the old tower.

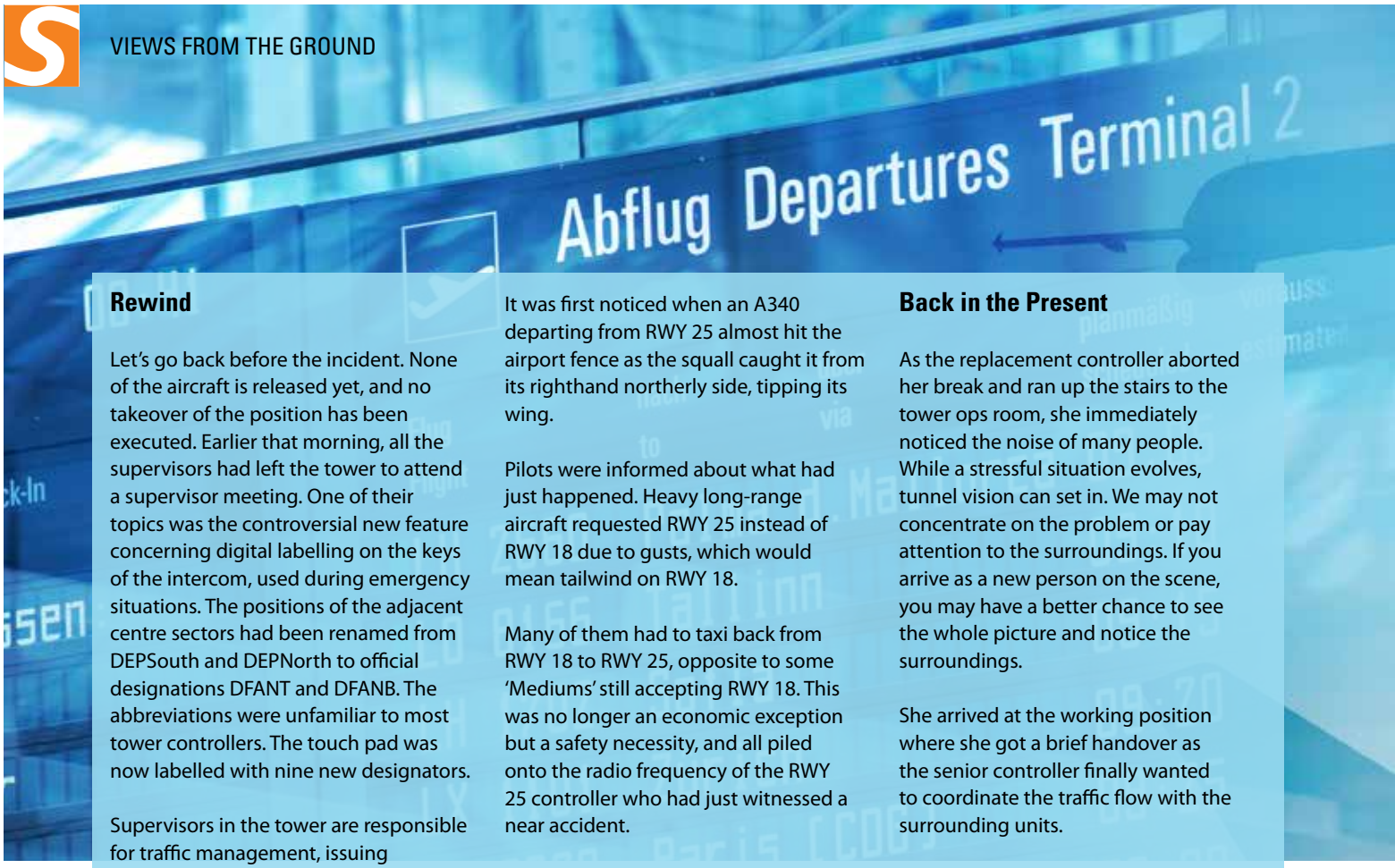
Generally, departures to southerly directions were assigned RWY 18 for departure. Pilots would sometimes ask to depart for these directions from RWY 25 as an exception. This would save taxi time when parked at the north-easterly Terminal D/E. If traffic would allow, we would grant their requests, the release being issued by the RWY 18 controller to the RWY 25 controller. However, this caused delay as these aircraft were not clear of RWY 18 departures until some distance had been flown.

At the time of the incident, three aircraft had been released by the RWY 18 controller in this way. During that time, he would hold his departures as they would conflict with the "exceptions". Shortly after issuing the release, the RWY 18 controller was relieved by a colleague. The controller told his relief that there were two "exceptions pending". During the handover briefing, the first of these three aircraft passed by in front of the tower window. The controller handing over his position was, of course, referring to the two pending aircraft. However, the controller taking over position interpreted that the first of these two aircraft had just passed by.

"An hour later, things suddenly changed. Unexpected storm gusts rolled over the airport."

When the next "exception" passed, she issued the take-off clearance to her RWY 18 departure. As the aircraft started to roll, the third "exception" went airborne from RWY 25. The two aircraft missed each other by 1/2 NM, same altitude. Both had been sent to different frequencies, so there was nothing to do except warn the next sectors, hoping they could fix the problem. However, the RWY 18 controller pushed the wrong button on her intercom and warned the wrong sector.

When the controllers were later interviewed, it was not clear whether the off-going controller had told his replacement that *"there are two more exceptions"* or if the incoming controller understood *"there are two exceptions"*.



Rewind

Let's go back before the incident. None of the aircraft is released yet, and no takeover of the position has been executed. Earlier that morning, all the supervisors had left the tower to attend a supervisor meeting. One of their topics was the controversial new feature concerning digital labelling on the keys of the intercom, used during emergency situations. The positions of the adjacent centre sectors had been renamed from DEPSouth and DEPNorth to official designations DFANT and DFANB. The abbreviations were unfamiliar to most tower controllers. The touch pad was now labelled with nine new designators.

Supervisors in the tower are responsible for traffic management, issuing capacity slotting if needed, among other tasks. However, it was a beautiful day – no problems. When there was no supervisor available, tasks like traffic reduction were performed by a senior controller, one of whom was present. Because nothing out of the ordinary was going on, the active supervisor decided to go downstairs and join the meeting. The senior controller was working RWY 18 but it was felt that, due to the low traffic, he could handle both.

Things were easy, and the flight data assistant (who was relieved) stayed at the position chatting with a friend. Two technicians were working near the RWY 25 controller replacing an old radio panel.

When the RWY 25 controller was relieved for his break, he took out his camera. He wanted some photos for his website, standing between the RWY 25 and RWY 18 working position. Noise in the small ops room increased, but nobody complained since traffic was low.

An hour later, things suddenly changed. Unexpected storm gusts rolled over the airport. Was it unexpected or was there no one present on the supervisory position, where things were displayed on a screen?

It was first noticed when an A340 departing from RWY 25 almost hit the airport fence as the squall caught it from its righthand northerly side, tipping its wing.

Pilots were informed about what had just happened. Heavy long-range aircraft requested RWY 25 instead of RWY 18 due to gusts, which would mean tailwind on RWY 18.

Many of them had to taxi back from RWY 18 to RWY 25, opposite to some 'Mediums' still accepting RWY 18. This was no longer an economic exception but a safety necessity, and all piled onto the radio frequency of the RWY 25 controller who had just witnessed a near accident.

Workload increased manifold in seconds, too quickly to influence the situation. The spotter was now blocking the view between the controllers needing to do coordination. No time to send technicians away as the board had been dismantled. No time for the flight data assistant to realise silence in the small room was an utmost necessity. No time for the senior controller working RWY 18 to get out of position to reduce traffic.

A natural reaction when faced with an overload situation is to solve it by focussing on the immediate task. There is no time for rearranging the surroundings.

Sure enough, questions started coming in to the RWY 18 controller about releasing those heavies from RWY 25, as they had spent time taxiing back and forth on the airport and were in urgent need to depart.

The controller on RWY 18 released three of them, while on the phone trying to arrange position relief early, so he could take over supervisor tasks to stop inbound traffic. There was no direct number to the three conference rooms. So he took the direct link to the recreation room of the controllers. Since it was break time, it took some time until someone picked up the phone.

Back in the Present

As the replacement controller aborted her break and ran up the stairs to the tower ops room, she immediately noticed the noise of many people. While a stressful situation evolves, tunnel vision can set in. We may not concentrate on the problem or pay attention to the surroundings. If you arrive as a new person on the scene, you may have a better chance to see the whole picture and notice the surroundings.

She arrived at the working position where she got a brief handover as the senior controller finally wanted to coordinate the traffic flow with the surrounding units.

She saw the departing aircraft pass in front of her, expecting one more. The senior controller did not stay behind her to check his last clearances, trusting that she had understood correctly what he had told her. His mind was firmly fixed on his new task.

He grabbed the phone at the supervisor position, as "number two" of the "exceptions" passed in front of the RWY 18 controller.

Thinking "this is number two", she took her microphone and issued the take-off clearance to her long waiting departure from RWY 18. At this moment, the third aircraft started rolling from RWY 25.

The RWY 25 controller quickly noticed what was happening and shouted across the ops room: *"You have it under control?"* This interaction was visually blocked by the 'spotter' and audibly impeded by the excessive background noise. He had no time to pursue this any further.

When the RWY 18 controller realised what was happening, she had already sent off her departure to Departure Radar. Seeing the two aircraft approaching each other, she pushed a button on the intercom to warn Departure Radar of the conflict. However, she hit the wrong one and

"Surprise: stress and overload are bad partners in solving problems."

warned the wrong sector. She had studied the new names of the intercom in her briefing documents, but had used the old label for over twenty years. This is another symptom of stress: we fall back into known patterns.

The two aircraft missed each other, coming as close as 0.5 NM on their SIDs.

What did we Learn?

Surprise: stress and overload are bad partners in solving problems. We learned about a senior controller suddenly confronted with three challenging and stressful tasks: solving the traffic puzzle, finding a replacement, and reducing traffic flow. Doing three things at a time, even if only anticipating them, distracts us from doing one thing right. Thus, he missed the proper handover of his position.

So what did we change at my old airport? We made it a rule, that either the Supervisor or Senior Controller performs only one task: Supervision. This meant restrictions in so-called "early goes" or "leave days" as the position had to be occupied by a person.

A handover/takeover checklist was created and implemented nationwide, and it was made a rule that the controller being relieved stays behind the position until all significant aircraft are processed by the replacement.

We demanded and succeeded in having the intercom relabelled to its old names, as labelling a button made no difference to the receiving end.

Private talks and activities by non-active controllers in the tower OPS room were suspended. People not needed on the flight data position (at times it was occupied by two) were to spend their time downstairs.

Technical repairs were to be coordinated with the supervisor before commencing, to be stopped at any time.

As a bonus, we printed papers drawn into plastic strip holders with the names of the Departure Routes in large print, enough to lay one across the electronic departure data screen for each released aircraft. Once a released aircraft had passed the end of the runway, it was to be removed. Nowadays with the tower flight data processing system (TFDPS), the entire runway is coloured red, a more modern version of my plastic solution.

These actions do not prevent stress during abnormal situations, but they make it easier to focus attention on the main task of solving a sudden problem.

No, my boss did not have to close the tower, and he never intended to, but I think we proved that this method would reduce incidents in a much more effective way. Things change. These days there is a new tower, a new runway, new equipment and new problems. But the systemic method of solving problems remains effective.

Sebastian Daeunert was the Safety Manager of Frankfurt Tower until retirement in 2021. He worked as an active TWR/APP controller for 15 years before getting into safety management and human factors. He now works in the EUROCONTROL/ IFATCA prosecutor expert scheme and holds presentations at EUROCONTOL Just Culture Committee and the Human Factors Task Force.

HOW ONE INCIDENT CHANGED MY APPROACH TO HANDLING THE UNEXPECTED

Reflecting of our own experience of handling surprise is essential to learn, and also to help others learn and be ready. **Glen Watson** explains what he learned from an incident as a controller.

Introduction

Air traffic controllers are highly skilled and extensively trained professionals who take pride in delivering a safe and expeditious service to airline and airport partners. With much theoretical, simulator, and live on-the-job training, followed by continuous monitoring and assessment, the job involves continuous planning ahead, maintaining situational awareness and making split second decisions under pressure. Most of us even thrive on it. Yet behind all of this, no matter how experienced we are, how much planning we do, or how routine the shift may be, the controller is human, and humans are vulnerable. We experience visual and auditory misperceptions, memory distortions, biases of judgement and decision-making, and of course, we are affected by unexpected or threatening events.

Every controller will have, or will be, caught out by such events. These events can range from routine (e.g., an unexpected go around) to critical emergency situations. While there is much research about surprise and also the startle effect on the flight deck, it is less common in ATC circles. We all know it exists, but how proactive are we in being prepared or spotting the warning signals? We need to recognise that we cannot train for every eventuality, we cannot engineer this out of human systems, and we cannot expect to never be caught out by it.

Incident

The incident occurred at night-time in good weather conditions, 25 minutes before the end of my shift. It had been a busy shift and I had been tasked with controlling the landing runway. Issuing landing clearances to the endless conveyer belt of arriving aircraft is something I had hundreds of hours of experience of doing. All was going well and nothing out of the ordinary was occurring.

The ground controller had instructed an aircraft to hold short of the runway, and upon making contact I reiterated the instruction to hold position. My attention was drawn back to the landing traffic which was now 30 seconds from touchdown. Nothing surprising here, this is a regular thing at my airport. As part of my scan out of the tower windows, the corner of my eye happened to notice the illuminated tail of the waiting aircraft to be moving very slowly forward. In darkness amongst the sea of aerodrome lighting I couldn't quite be sure what I was seeing. Was my brain playing tricks on me? The crew have acknowledged to hold position, there is a red lit stop bar in front of them, and the bright landing lights of the Airbus shone down on them. It is impossible that they are moving, right? At that very moment, the feeling was overpowering. I was unable to comprehend the situation and for those few seconds I was merely a human; training and experience did not seem to enter the picture. I was both startled (because I experienced a rapid stress response in reaction to a sudden event, see Landman, et al., 2020), and surprised (because the observed information did not match my expectations).

"We need to **expect** to be surprised and develop ways to manage the situation before it becomes critical."

What is the startle effect?

The startle effect is the physical and mental response to a sudden intense, threatening, and usually unexpected stimulus. Most of us are familiar with the fight, flight or freeze physiological reaction. However, there is also an overwhelming automatic cognitive response in which the individuals' ability to perceive and process stimuli is considerably restricted. Higher order functions required for decision-making are significantly impaired and in the most extreme situations these functions are completely overwhelmed, known as cognitive incapacitation. Performance decrease can range from three to 10 seconds, and studies have shown that the recovery period for information processing can take up to one minute after the startling event (Martin et al., 2012).

Clearly in the ATC environment, full of incoming sensory information which requires accurate processing by the controller, any loss of cognitive processing ability – even for three seconds – increases risk. Put simply, our brains become overwhelmed. This can lead to inappropriate decisions, communications, and actions, or none at all. Perhaps most alarming is that the individual has little ability to realise the predicament they are in.

What happened?

Going back to the situation, it's clear I was experiencing the startle effect. My cognitive functions were impaired, and I was unable to process the stimuli my eyes were receiving. The aircraft was rolling forward, it had crossed the stop bar and it was now moving towards the runway edge of an active runway (a runway incursion). I had not even considered this possibility and I was in the startle danger zone. It was only after the event that I recognised one simple action had a profound effect on the outcome: I verbalised what I thought I was seeing: *"Is he rolling forward?!"* was all it took. Drawing the attention of my colleagues, I was immediately met with shouts of *"yes!"* and *"send it around!"*, snapping me from my state of reduced mental capacity and back into 'controller mode'. Training kicked in and actions were immediately taken to make the situation safe.

What did I learn?

Any controller will tell you that when you have been involved in an incident, the first person you blame is yourself. *What did I do? Did I cause that? Why didn't the aircraft hold position? Did I miss a readback?* Yet we are lucky to work in a sector which places lesson learning high on the agenda. After reflecting on the incident, I learned these things:

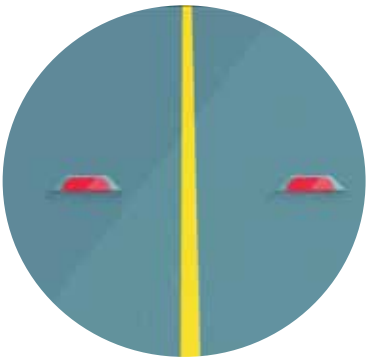
1. No matter how well trained or experienced we are, things will surprise us. We are human – we need to **expect** to be surprised and develop ways to manage the situation before it becomes critical.

2. **Verbalising** has the ability to break startle. This was the single action that reset my cognitive abilities. I now verbalise much more, even before a potential situation has been allowed to develop, to help make sense of what is developing and enable my team members with their extra perspective into my situation.

3. **"What if thinking"** allows us to consider potential threats and be on the lookout for when things go wrong. Questions such as *"What if the aircraft doesn't stop at the stop bar?"* prime our brains for those potential surprise moments and enable us to begin considering the action plan should the situation arise. This also helps us to avoid complacency and maintain situational awareness.

4. We need to **train proactively** for surprise. Simulator exercises including unexpected situations help to recognise how surprise situations may develop and build strategies to help mitigate the effects of surprise.

Talking about unexpected events and our strategies to handle them may also help others to be more ready for those times when they experience something similar. My incident changed my approach to handling the unexpected.



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JET BLAST: HOW SMALL CHANGES CAN LEAD TO BIG OUTCOMES

Jet blast is an aerodrome hazard and is mitigated in a number of ways. Whilst pilots are aware of the implications of familiar aircraft, new aircraft can introduce small but unknown changes, with significant effects, as **Ulf Henke** explains.

KEY POINTS

- **Seemingly minor changes to the type and operation of aircraft can have major effects.**
- **Sometimes we may not be aware of the side effects caused by our actions.**
- **Sharing information on negative surprises may help to prevent similar events in the future.**

Airborne aircraft create wake turbulence, with possible hazards to subsequent or crossing aircraft. To avoid a negative impact on the subsequent aircraft in the air, appropriate wake turbulence separation must be applied. ICAO and national as well as supranational entities have, of course, set standards on minimum separation distances between aircraft.

On the ground one of the main hazards is the jet blast caused by the operation of aircraft engines. Here, there are no such minimum distances (of course, the aircraft are not supposed to touch each other for many good reasons).

Jet Blast Risks

The potential risks resulting from the jet blast of an aircraft in operation on aerodromes is well known. According to ICAO Document 9157 (Aerodrome Design Manual) Part 2 Appendix 2, "jet blast velocities above 56 km/h are considered to be undesirable for personal comfort or for the operation of vehicles or other equipment on the movement aera". To avoid the hazard of jet blast velocities, blast fences are used at aerodromes to reduce or eliminate the detrimental effects by deflecting the high air velocities. The application of either fences or screens becomes necessary when it is impractical to provide a safe, reasonable separation between aircraft engines and people, buildings or other objects on the aerodrome.

"On the ground one of the main hazards is the jet blast caused by the operation of aircraft engines."

Many aerodromes permit aircraft to taxi on the apron only at minimum engine speed. In addition, so-called break-away areas have been established to ensure the necessary appliance of break-away thrust only in areas where it is safe to do so. Some aerodromes restrict the application of thrust even further.

Every once in a while, a flight crew is surprised that whilst taxiing quite slowly; having almost reached their parking stand on their two or ten o' clock position, the aircraft is too slow to coast the turn onto position. The solution: a little more thrust, and the ninety degree turn onto the stand is a success. This is likely to happen at nearly all aerodromes in the world. In some cases, the ground handling crew near an aircraft parked on the opposite side of the taxi lane got a little shaken up by the wind velocity. The passengers

boarding the aircraft had to grip a little tighter to the handrails of the rear stairway of the aircraft they were about to board. Luckily, in these cases no objects at the stand on the opposite side of the taxi lane were blown against persons or the parked aircraft.

"On the passenger buses, some windows were dented inwards, while others were shattered by the jet blast and shards blown into the buses."

Fuel Savings and Jet Blast

For environmental reasons and fuel saving, there has been an increase of single-engine or less-than-all-engine-running taxi operations. By shutting down one or more engines of an aircraft after landing, airlines can significantly reduce carbon and nitrogen oxide emissions produced by taxiing aircraft on the movement area. Especially in the case of four-engine aircraft, when the taxi procedure is done using just two engines, a considerable amount of fuel can be saved.

However, there are some issues with this practice. For instance, single-engine taxiing causes greater jet blast on the remaining active engine to move the aircraft forward, generating a strong asymmetric force that could also unbalance the aircraft. (The correlation between thrust setting and blast velocity and the allowed taxiing speed may differ depending on the mass of the aircraft, wind direction and speed, height above sea level, temperature and other factors.)

When taxiing in with the starboard engine turned off, left turns require a considerable increase in thrust. Many stands at an aerodrome are placed on a ninety-degree angle to the taxiway centre line. This may be challenging to the flight crew when taxiing in with one engine turned off and at the same time having to avoid a thrust setting which will result in exhaust velocities above the predetermined 'normal' speeds. This is especially problematic if, on the other side of the taxiway, ground handling or passenger boarding via mobile stairs is in progress.

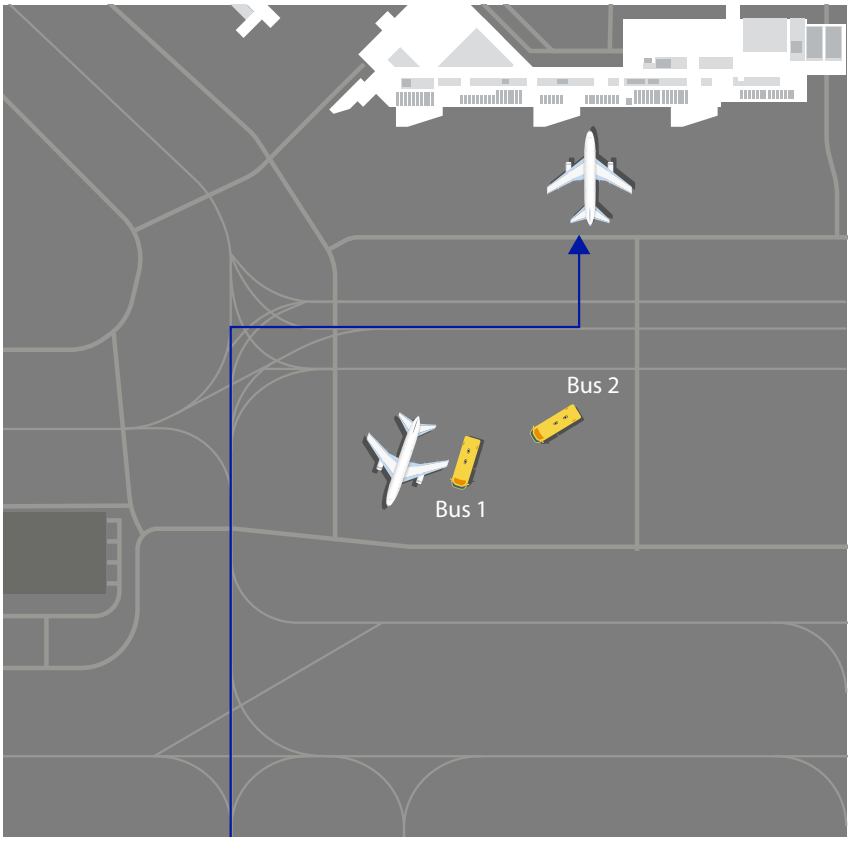

Figure 1: Schematic drawing: Location of the passenger buses in relation to the aircraft

Even worse for those aircraft with one (or more) engines turned off are so-called taxiing in/taxiing out stands via the same taxiway. Flight crews may expect a turn of more than 180 degrees onto the stand, with a predefined thrust setting around or just a little above idle, which is not easy to perform. So some airlines refuse to execute such operations at low visibility, at wind speeds of over 25 knots, or when a sharp turn is needed. (The engines that may be shut down are predefined by the manufacturer of the aircraft for technical reasons, not by operational needs.)

B748 Surprise

This example happened at the beginning of the last decade. I received the information from those involved during my part of the investigation. A major carrier introduced the Boeing B747-8 (B748) into its fleet. According to the information I received, the B748 may be operated with the same type rating as her older sistership, the B747-400 (B744). Prior to performing commercial operations, crews that had a type rating for the older B744 only need familiarisation training on the new subtype.

While taxiing on the apron, the flight crew of the B748 used a recommended very low thrust setting, but as a result the aircraft taxied rather slowly. To counter this, the thrust setting was raised a little prior to curves, while on straight portions of the routing the thrust setting was lowered again. As a result, everything went well. On the last two hundred metres before entering the final parking stand, the taxiway was inclining but only within the limits set by ICAO in Annex 14 and its co-applicable documents. However, the aircraft lost taxi speed due to the gradient. Since the parking stand was located at a ninety-degree angle to the left, the crew increased the thrust setting to make a smooth turn onto the position. The taxi speed was still decreasing, though, and the ninety-degree turn was coming closer.

The thrust setting was further increased, but because of the incline and the low speed of the aircraft, the aircraft was still slowing down. While turning onto the stand, some witnesses observed that,

after performing the first 45 degrees of the turn, the aircraft came to a stop momentarily and then continued after additional thrust on engines No. 3 and 4 was employed. Other witnesses recalled that the aircraft made the full turn without stopping, but they also heard that the thrust on engines No. 3 and 4 was raised considerably. After final parking the engines were turned off and post-flight activities started by the flight crew, no abnormalities had been observed from inside the flight deck.

"What was not realised by the flight crew while taxiing was that there are some differences in the behaviour of the B744 and the B748."

The situation was totally different on a parking stand on the opposite side of the taxiway. This stand is located about 150 meters south-southwest of the stand that the B748 had been taxiing onto. At the time, the B748 entered its parking stand, ground handling of another large aircraft on the position behind it was in progress and passengers were inside two buses waiting for the cabin crew to release the aircraft for boarding. The passenger buses were parking on the aircraft stand located on the opposite side of the taxiway, the first one facing south, the second one facing southwest, in a sort of V-shape formation.

On the passenger buses, some windows were dented inwards, while others were shattered by the jet blast and shards blown into the buses. In the bus closest to the parked aircraft, the flying shards broke a window on the opposite side. Luckily, the passengers suffered only minor cuts and bruises.

How and why did the incident happen? The flight crew decided to taxi with a minimum thrust setting since they were taxiing very slowly to ensure a safe passage on the apron. Only, when necessary (in due distance before curves), they raised the power setting a little. The investigators of the carrier reported that the flight crew taxied the aircraft according to the recommended thrust setting. Sounds safe, but why did the incident happen the way it did?

The fact that there was a gradient (within the limits set by ICAO and EASA) on the last hundred metres, and that the flight crew decided to taxi with minimum thrust setting, were contributing factors. Additionally, what was not realised by the flight crew while taxiing was that there are some differences in the behaviour of the B744 and the B748. The B748 reacts even more slowly to thrust lever inputs than the B744, although the B744 is already well known for her slow reaction on thrust settings. The crew gave sufficient thrust for a ninety degree turn after early thrust corrections, but several seconds passed until the engines reacted to the lever inputs. Since the flight crew was afraid to come to a stop while taxiing the curve, they set additional thrust on the two starboard engines while taxiing onto their parking stand.

The V-shaped formation of the parked passenger buses may have accelerated the jet blast velocity of the engines, creating a 'Bernoulli effect' as a result. This would have channelled the air in between them and thus accelerated it, blowing some side windows out of the passenger buses. (Note that the European Union has set minimum requirements on the stability and minimum permissible forces to withstand for front side windows of cars, buses, and trucks, but there were no minimum requirements at the time of the incident on allowable forces to side windows.)

A new aircraft may bring surprises, even to experienced crews. Things may happen not as expected and the crew may find out that what they thought was a good idea turns into a problem. Realisation may come too late.

The case studies urge the use of caution when operating the thrust lever while taxiing on the apron. Thrust levers are potent hazards and the liability, in most cases, rests with the flight crew.

"The case studies urge the use of caution when operating the thrust lever while taxiing on the apron."

Ulf Henke joined Fraport's Apron Control Office in 1986 serving in various functions and was Head of Apron Control Office for more than a decade. In 2008 until his recent retirement, he affiliated to the Safety Management System of Fraport. Beside his duties at his home airport, he facilitated several international airports to introduce a mature safety management program.

IS THAT THE FIRE ALARM? SURPRISE IN THE SIMULATOR

In your unit, how confident are you that controllers and others would act as imagined in the event of a fire alarm? In this article, **Lucy Kirkland** recounts what happened and what was learned when controllers participated in a full simulation of an ATC evacuation.

KEY POINTS

- **People exhibit a variety of reactions to unusual and threatening situations such as an evacuation alarm.**
- **Our assumptions about what we and others know and how we and others would respond to an unusual situation can be unrealistic.**
- **Simulation of unusual situations can reveal much more than discussion.**
- **The wider system impact of a local unexpected situation should be considered.**

Background

Early in my career, the fire alarm sounded while I was in the visual control room (VCR). I happened to be there in a non-operational capacity as I was not yet a valid ATCO. I watched as both ATCOs and the assistant looked at each other, rather than immediately reacting, for confirmation that what they were hearing and observing (a red flashing light) was an evacuation alarm. This internal questioning took a short but significant amount of time. Gradually, as the alarm continued, there was a conversation about whether the evacuation should commence. Someone made a decision, the evacuation checklists and action cards were obtained, and the process was started.

It was only then that I realised that, as a non-operational member of staff, I should already have left on hearing an alarm; I was not acting with immediacy either. I had joined in the initial lack of reaction. Despite thinking we should be evacuating, I was waiting for someone senior or operational to lead the decision and felt confused about why that was not happening. A long walk down the stairs followed. By the time I had reached the bottom, and luckily for the staff on duty that day, the fire alarm was declared a false alert and the evacuation stood down.

More recently, I observed human behaviour on hearing a fire alarm once again. This time it was during my child's primary school prize-giving at the end of the summer term. It is a very large school and there were many hundreds of people in the hall. The children were sitting with their teachers and my husband and I were sitting in the audience. All the heads of various departments had just arrived, and we were about to start, at which point the fire alarm sounded. Nothing happened. We questioned each other about whether it was a fire alarm. We looked around the room and observed what seemed to be confusion and disbelief from the teaching staff, who were also looking around the room. A growing sense of unease was building at our own inaction, but we were struggling to find validation of our belief that this must be a fire alarm. Surely if it was, others would have jumped up and started to leave?

Decision Making in Group Situations

The Smoky Room Experiment demonstrated how people can be influenced by those around them. Observation of passive behaviour in response to emergency stimulus drives further passive behaviour, despite obvious environmental indications which should drive action.

We talked some more and decided that, regardless of what everyone else was doing, we were going to leave. What else could it be apart from the fire alarm? A few other parents were beginning to stand up, which would have validated our thought process. As we neared the exit, I asked a teacher why they were still not evacuating, she stated that they were waiting for the headmaster to indicate it was an evacuation. This was similar to my reaction 20 years earlier. We continued to leave, noting finally that many other people were beginning to move. Later, after all had successfully evacuated, we spoke with the headmaster in the playground. He was horrified that the teachers had been waiting for his nod. He informed us the procedures were that they evacuate immediately with their allocated groups of children as practised, although he was still standing in the hall as we left.

What are the similarities between these two scenarios? Human behaviour is influenced by the behaviour of other people around them and people may require confirmation of an unusual situation prior to reacting. Various studies have shown that we are more likely to go with the majority, even when we think they might be wrong. Additionally, the feeling of surprise, which a fire alarm can elicit, drives both emotional and physical responses which can delay and impede decision-making.

One way of counteracting these natural reactions is to repeatedly train the correct action to take when experiencing unusual situations thus enabling embedded trained reactions to overcome more inbuilt natural tendencies.

Importance of Training for Unusual Situations

In air traffic control we train for the unusual to bring it closer to the routine. If we can make the unusual more routine, we can improve our reaction and adaptability to unusual situations. A unit training review indicated that whilst discussion and walk through of evacuation and the impact of such takes place on an annual basis, there had never been a full simulation of an ATC evacuation due to the impact on live traffic. Recently, the simulator had been significantly upgraded allowing for much more realistic training scenarios. A plan was put in place to run one-hour enhanced simulation sessions for all ATCOs in both tower and radar positions, incorporating an evacuation scenario. The aim was to refresh and embed existing knowledge, in line with EU340 requirements, and enable experience of the surprise element of the evacuation.

For maximum impact, as far as possible, the ATCOs were not aware of the plan for their simulated run. And for the most part, controllers did not tell others what to expect. This shows that those ATCOs involved in the simulation saw value in the learning experience. Even with those ATCOs who knew what was going to happen (due to their involvement in planning), the reactions were insightful.

The simulation commenced as a busy and fairly complex combined run, either as aerodrome control (air and GMC combined) or radar control (intermediate and final sectors combined). Once settled into the run the 'supervisor' at the back of the room played a loud recording of the unit first stage fire alarm (possible fire, investigations underway, get ready to evacuate). Five minutes later, a recording of the second stage fire alarm was played loudly (fire confirmed, all staff evacuate). Once 'evacuated' the ATCOs were given a few minutes to regroup (to reflect a real evacuation). They were then briefed on the second part of the exercise. This was to return and reopen the sector (now split due to traffic levels) and recommence the operation. The second part of the simulator run restarted 10 minutes later and reflected a busy sector split session reopening operations after airport closure.

Reactions to Evacuation

On the first stage alarm sounding, immediate reactions ranged from none (they continued as if it was not happening) to much more impacted situational awareness due to interrupted thought processes and a startle effect of short-term confusion. At the second stage alarm, any possible startle effect had subsided, but an element of disbelief and confusion remained for some which influenced some decision-making and reaction.

As well as the immediate emotional reaction to the situation, there was a more uncomfortable realisation, for some, that their embedded knowledge of procedures and checklist locations was not as they had anticipated. Some of this may have been attributable to the startle effect where, for a short time, there can be a feeling of confusion. However, comments such as "I need to go and read over that again" at the end of the simulation showed recognition that their surprise was not just a response to the fire alarm, but a reflection on their own knowledge, which was not what they thought.

Startle Reaction

Whilst often mentioned in conjunction with pilots, this may also be observed in ATCOs in response to a threatening situation. Physiological responses, including adrenaline release, can lead to short-term confusion and impact task completion and situational awareness.

"As well as the immediate emotional reaction to the situation, there was a more uncomfortable realisation."

Lessons Learned

As expected, all ATCOs managed to complete the ATC evacuation safely. The majority of the ATCOs felt that they had benefitted from simulated evacuation practice and that it was far superior to previous 'round the table' discussions. The focussed listening of the evacuation messages (two different voices for the two-stage alert) and experiencing the consequence of each message was more impactful than theoretical discussions. They reflected on the use of the checklists and how better knowledge of their location and content may have aided their response time and reduced the impact of the situation. Communication with, and implications for, other stakeholders involved in an ATC evacuation was recognised as a possible blindspot, requiring more understanding about the scenario.

The ATCOs felt that their responses would be enhanced if they experienced the scenario again.

From a wider point of view, there was acknowledgement that many assumptions were made regarding the reaction to an ATC evacuation on a system-wide level. Subsequent discussion highlighted many clarification questions that the high-level procedures do not cover. An ATC evacuation impacts not just local aircraft on frequency but also the local airport stakeholders: fire service, terminal management, and airfield operations. How do they handle the surprise call informing them, "ATC are evacuating"? Additionally, it is important to understand subsequent impacts on traffic movements and staff resourcing when reopening the sectors. A working group is to be set up to take the lessons learned from the simulation sessions. It will bring together all stakeholders to ensure that, in the event of an actual evacuation, the most effective outcome is achieved with the least disruption to the system. The simulation will be repeated periodically to continue to embed further learning.

"The ATCOs felt that their responses would be enhanced if they experienced the scenario again."

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AIR CON DOWN

OPS ROOM AIR-CONDITIONING SYSTEM FAILURE

Sometimes the failures that can catch us out are relatively simple. In Malta ATS, it was an ops room air conditioning failure. **Francis Bezzina** explains what happened, and what was learned.

What Happened on the Day

It was around 16:00 on 9 June 2019 in the OPS room in Malta ATS. An approach controller heard a loud, unusual noise. The vibrating sound seemed to come from the air conditioning (A/C) ducts. Everyone in the OPS room is familiar with the noise when the A/C compressor is activated, but this sounded louder and different.

The technical section was informed and a few minutes later, the fire alarm sounded inside the main OPS room. Within a few minutes another fire alarm, which covers the equipment room, also activated. Smoke was now evident in the OPS room, the air conditioning plant room and the corridor leading to the OPS room. In response, ATSEPs switched the FM-200 fire suppression system to manual. FM-200 is a harmless gas which, if triggered, lowers the oxygen level by 3% to extinguish a fire if present, but leaves enough oxygen for people to exit the rooms.

ATSEPs analysed the situation in the OPS room and concluded that frozen gas was being emitted from a ruptured air conditioning pipe. On further analysis, it was found that the leak was due to a metal fatigue crack in one of the internal compressor unit copper pipes. As a result of the crack, there was a total loss of refrigerant gas, and consequently this gas escaped into the OPS room. This produced a dense cloud of smoke, which filled the entire room, and the adjacent equipment room.

The traffic level was significant, and the main concentration of aircraft was with Malta West Sector. (During this time of day ACC is divided in two sectors – Malta West and Malta East – with an Executive and a Planning controller in each position.) All IFR and VFR departures were stopped. The ACC sector was collapsed to one sector (from two) to reduce the number of ATCOs in the OPS room. The ATCO supervisor and a group of ATCOs remained in the OPS room handling traffic. Some ATCOs needed medical attention and one ATCO (APP) was hospitalised for observation.

In the meantime, the fire service was notified and were on site within a few minutes. As soon as they arrived on site, they were informed that it was not a fire, but refrigerant gas. The fire officers confirmed that, since the AC units were recently installed, the gas was probably nontoxic. Meanwhile, as soon as the crack was identified, an ATSEP tried to block the leak. Due to the high pressure involved, this was impossible (the nominal press is in excess of 20 Bar, while a typical car tyre pressure is approximately 2 bar or 32 psi). Fans were immediately placed inside the OPS room near the doors, to disperse the gas, and after 30-40 minutes, the room was almost cleared. The spare AC unit was switched on. At 16:53, operations were resumed back to normal.

This was a situation that was never anticipated, nor practised in any contingency training at MATS. An internal investigation was launched to build a clear understanding of the failure and how to mitigate for such circumstances and reduce the chance of such occurrences. Meetings were organised to discuss and review the findings and resulting safety recommendations with ATCOs and ATSEPs.

Equipment

The faulty A/C part was replaced and tested by the supplier, and resumed back in service, with a separate investigation by the manufacturer. All types of unearthing gases, fire suppressants, or any other gases or substances that might leak into any of the working areas must be documented and certified by a competent authority. In this case, while the refrigerant (R410A) used was nontoxic, in big amounts it can cause dizziness and nausea. This is why an ATCO needed hospitalisation.

Two mobile air extractors were also purchased, modified internally by the technical team. These extractors are mounted on wheels and can be stored to be available at short notice, and can clear the OPS room in a few minutes. The extractors were tested in the OPS room to check their noise levels and included in the ATSEP contingency procedures. Ventilation in the OPS room was also modified.

Contingency Ops Room

The incident was a reminder of the importance of having a secondary standby operations room close to, but independent from, the main operations room. Work on the new contingency OPS room was given top priority to assure service continuity when the main OPS room is compromised. The contingency OPS room is now fully equipped and operational, with separate controller working positions

and servers for all functions, along with dual supplies. This can be activated in minutes. A contingency changeover is done every three weeks with different ATCO-ATSEP shifts involved.

Procedures and Training

A procedure is needed to outline what operational and technical supervisors are expected to do when faced with a situation, such as fire, smoke etc., when they have to move out of the main OPS room. The supervisor manuals had the contingency procedures updated, and monthly exercises are conducted involving management, ATCO and ATSEP teams. These cover the termination of service from the main OPS room, with OPS continued from the Contingency OPS room.

Some Conclusions

It is difficult or impossible to cover all events and occurrences in your contingency setup, but it is important that we try, especially when dark days occur. A shock event – no matter how basic it seems – is always a possibility. Management teams need to give priority to contingency training and exercises. It will build confidence on the day when luck looks to the other side.

We are again updating our contingency and emergency response plans. It is of utmost important to listen carefully from the ground level because that is where the experience lies. Be close to the OPS room and technical areas if you want to know the risks that may someday come to haunt you. Share, discuss, and brainstorm, and don't be afraid of constructive criticism; this is the place where dragons can be identified and stopped in their tracks. And finally, show appreciation for the contributions from all staff, those are the people that will probably save you on the day.

Francis Bezzina is Senior Head for Safety, Quality, Security and Compliance (SQSC) at Malta Air Traffic Services. He has an MSc in Air Safety Management, and 26 years in the engineering domain of MATS mainly on ATM systems, Surveillance and Communications, plus 16 years as the Head of the SQSC section.

HUMAN AND ORGANISATIONAL FACTORS Q&A

JUST CULTURE FOR ALL, BY ALL

Lea Sophie Vink
at Austro Control

What is a significant change planned within your organisation that has relevance to human and organisational performance?

Over the last few years, we have been working on expanding our Just Culture concepts and policies to the entire organisation. Just Culture continues to be one of our most important areas of development. We are proud to have had a relatively mature policy since 2015 in the Air Traffic Management department. However, since last year we have now expanded it to cover every employee in the company. This represents a major philosophical and practical shift in the way we manage and administer Just Culture. Specifically, it means changing the way we think about occurrence investigations, human error analysis, lesson learning and improvement processes. The main goal is to build stronger trust between operators and staff with management as we, like so many others, come out of the Covid pandemic.

Why is this change necessary? What is the opportunity or need?

Our original Just Culture policy applied to front-line operators only. Specifically, it was implemented exclusively through our Air Traffic Management department. The policy was developed around the concept of occurrence management investigations which focuses heavily on the 'last line of defence.' This means most investigations focus on what the ATCO did or did not do and their contribution to occurrences. However, it is well established that safety events are precipitated by many contributing factors and often these are further away from the ATCO. Increasingly, engineering and technological issues mean that ATCOs are having to deal with different kinds of scenarios. This means we need to be able to investigate further away from the front line. To do this, however, we need to improve the quality and frequency of reporting from other departments and areas of the company. So there was a strong need to implement Just Culture ideas to everyone. Added to this, our human performance research showed through the Covid period that 'trust' and 'acceptance of change' were two areas we could improve on across the company. Building a stronger Just Culture concept allows us to tackle both issues together.

What are the main obstacles facing this change?

Many ANSPs will be familiar with the idea that safety and Just Culture 'ownership' tends to diminish further away from front line operations. Teaching these ideas to staff who are not facing daily tactical situations is a challenge. Understanding how systematic factors and decision-making can contribute to acute safety events is also challenging since many of these concepts are abstract and foreign to staff who are not exposed to all the parts of our system. We have also had more practical challenges, such as, how exactly do you investigate a safety occurrence that may not result in mandatory reporting? And when you do investigate, who should do it?

Just Culture looks at concepts such as 'at-risk' or 'reckless' decisions being made, but how far back in the system should you go? For example, does a decision to force through a change even when it is not ready or mature enough and it results in a safety event constitute an 'at-risk' behaviour? Our new Just Culture policy now attempts to reconcile these challenges by looking at everything from decisions being made for future strategy through to project management and even training and recruitment behaviours.

What is the role of front-line practitioners? How is their expertise incorporated into change management?

Our Just Culture policy is a living, breathing policy that is constantly being moderated by our front-line staff. Our investigators and human factors staff have contributed to enhanced use of tools for more objective occurrence investigation. For example, as part of the process of triggering Just Culture committees we have developed a new human error analysis procedure which is now being rolled out in other areas. This was developed using expertise and data analysis from these practitioners.

What do they think about the change?

Our staff have been very enthusiastic about the changes. This year, we held a mandatory human factors training day for every ATCO in the company. They were all introduced to the new policy and shown how it will lead to our company taking greater responsibility for systematic issues, protection of individuals, and more objective lesson learning.

What has been learned so far, more generally?

Just Culture needs to be 'owned' company-wide for it to prosper. As automation rises and occurrences involve more decisions away from the ops room, people's behaviours and attitudes need to be held accountable and reporting maximised to maintain the highest safety standards.

SURPRISE AND STARTLE

Surprise and startle are words often used in the same breath. However, for several important reasons, the distinction should be clearly understood. In this article, **Captain Ed Pooley** explains some of the differences.

Surprise and Startle Response are Different Reactions

Surprise is *"an emotion typically resulting from the violation of an expectation or the detection of novelty in the environment"* (American Psychological Society, 2022). The startle response, meanwhile, is *"an unlearned, rapid, reflex-like response to sudden, unexpected, and intense stimuli (e.g. loud noises, flashing lights)"* (APA, 2022), a response which is sometimes colloquially described as 'fight or flight'. Surprise and the startle response are associated with fundamentally different neurological and physiological activity.

Simply put, surprise is a mismatch between expectations and reality, or something that is very unusual, while a startle response is associated with the almost instantaneous perception of a threat. An everyday analogy may occur on one's birthday. A surprise might be receiving a card or gift from an old friend whom you thought you'd never hear from again. A startle response might occur if you walk into your dark home to find all the lights switched on suddenly and several friends jump out from behind the furniture in your living room.

For pilots, an extremely small number of sudden unexpected situations are likely to trigger an immediate and involuntary 'startle reflex' in one of the pilots. It has been shown that this is quite likely to be followed by an irrational response, which is recognisable as such by the other pilot who is unlikely to be similarly affected at the same time. The available evidence indicates that a startle reflex that results in hazardous direct or indirect inputs to the primary flight controls – the most serious consequence – is most likely to occur during a relatively quiet period of flight and when no external visual reference is available (e.g., when in cloud or during dark night visual conditions over terrain with no significant lighting).

Research indicates that the activation of a startle response may directly affect information processing capability for up to 30 seconds and thereby have important implications for the affected individual's situational awareness and decision-making ability. It also appears that once this acute phase is over, a variable duration phase of continuing disruption to normal performance is likely.

Surprise is Common, Startle Response is Rare

Almost all encounters with a sudden unexpected in-flight situation may constitute a 'surprise' to one or both pilots in a multi-crew aircraft. Dramatic improvements in aircraft reliability and widespread compliance with comprehensive normal procedures mean that surprises are now fewer than in the past so that dealing with them is no longer an almost everyday experience. Nevertheless, the element of surprise is still at the core of a significant proportion of those occasional unwanted events.

The startle response to an unexpected or threatening event is so rare that most pilots will be able to complete their career without experiencing it themselves or having to react decisively to the consequences of a colleague experiencing it. In my own flying career, I did not experience a startle reflex at any time. Nor did I witness any of my many fellow pilots being so affected. I don't think my experience is particularly unusual. Few pilots will even know anyone who has had or witnessed a startle reflex event during flight.

"Startle reflex is not simply 'extreme surprise', and the recognition of the difference is important for risk management."

Risk Mitigation of Surprise and Startle is Fundamentally Different

Startle reflex is not simply 'extreme surprise', and the recognition of the difference is important for risk management. Although it is not easy to replicate surprise realistically in a full-flight simulator, it can be achieved with a little imagination and at the expense of more simulator time than the typical regulatory minimum. Effective mitigation of the risk for the relatively common 'surprise' reaction with no startle response for either pilot is increasingly being provided. Exposure to unexpected events during training sessions (in ways other than those routinely included) has been shown to be effective in reducing the risk of a non-standard response. Surprises alone leave time for a considered and rational response and are thus unlikely to need a change of control as an immediate response, or indeed as any part of the resolution.

Effective mitigation of the risk of those rare events that trigger a startle reflex-based response is more problematic since they are very rare. The propensity of individuals to experience startle response is variable and in respect of pilots in flight (which may or may not be different to the same propensity in other contexts) cannot be assessed. It has not yet been demonstrated that simply exposing pilots to *surprises* in a training environment can affect what is a physiological response. What is likely to be beneficial is enabling all pilots to distinguish a (rare) startle response in an unexpected situation from (much more common) surprise. This can help an unaffected pilot to recognise when their colleague has been affected and is unknowingly responding in a way that is leading to an unsafe condition requiring intervention. The importance of the Pilot Monitoring (PM) – especially if they are the junior crew member – having the confidence to act without delay, if necessary, cannot be overstated.

Remember that a Pilot Flying (PF) experiencing a startle reflex response will not recognise it themselves, so any attempt to engage normally with them will be temporarily impossible. If continued safe flight is being compromised, then the unaffected pilot must be prepared to intervene without delay and quite probably take over control temporarily. If the task of any such takeover of control falls to the junior pilot, then an unusually direct instruction may be required to retrieve the situation before it gets too difficult to do so.

Confusion about the important distinction between surprise alone and unexpected events that trigger a startle reflex response is widespread, and has important implications for risk mitigation training. Such confusion is evidenced by the fact that many pilot reports of 'surprise' events use the word 'startle' when it is clear from the narrative that no startle reflex occurred.

Find Out More

To understand the startle reflex as it affects pilots, I recommend Safety Briefing Note 06 on *The Risk of Startle Reflex* published by the Honourable Company of Air Pilots, an independent organisation which works to assist air safety (see references). This was issued in November 2021 and drafted by a global steering group of very experienced pilots, then finalised and formally approved only after peer review by around 70 other similarly qualified pilots. After it was sent directly to thousands of pilots working for commercial air transport operators worldwide, no adverse response was received.

Finally, if you prefer a different medium, a short (two minute) SKYclip showing a successfully resolved startle reflex scenario can be viewed at https://www.skybrary.aero/video/startle-effect-skyclip.

Captain Ed Pooley is an Air Operations Safety Adviser with over 30 years of experience as an airline pilot including significant periods as a Check/Training Captain and as an Accident/Incident Investigator. He was Head of Safety Oversight for a large, short-haul airline operation for over 10 years where his team was responsible for independent monitoring of all aspects of operational safety.

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DISPATCHES FROM HELL

REFLECTIONS ON SURPRISE AND PERSONAL RESILIENCE

Coping with unexpected events is part of the raison d'etre of military life. In this article, **Air Commodore Dai Whittingham** reflects on what he learned from two military surprises.

The catastrophic effects of the Covid-19 pandemic on our industry led to considerable discussion about resilience, a concept that means different things to different people, and that applies to systems, organisations and individuals. This exploration of personal resilience is just that – my personal experience, and yours will be different. However, there are some insights that might be useful, and they are offered in that spirit.

I am neither a commercial airline pilot nor an air traffic controller, but prior to my 10 years with the UK Flight Safety Committee I was a pilot in the Royal Air Force for 37 years and was lucky enough to fly fighters and a large 4-jet. I spent three years as a basic flying instructor and made a brief but late acquaintance with helicopters. I have also been a regulator for military flying activity.

When I was asked to speak at the EUROCONTROL/CANSO conference on resilience in December 2021, I was forced to think about my own resilience and why I had come through various 'testing' situations without too much apparent difficulty. I decided the answer lay in experience and especially the experience provided through training.

The Phantom Fire

In the early 1980s, I was flying the Phantom F4K from RAF Leuchars, in Scotland. We had been working with the radar unit at Benbecula, an island in the Outer Hebrides, and it was traditional to overfly the coastal airfield to say hello. There was heavy rain and very strong surface winds that had turned the sea into a churning mass of foam and spray. We arrived at the airfield boundary at 250 ft and about 500 knots but when I put on the reheat (afterburner) there was a large bang, prompting an immediate return to cold power. A few seconds later my attention was drawn to a large red caption which appeared on the left side of the instrument panel. It said "FIRE".

I duly informed my navigator and started the memory items, calling out as I did them. The drill was very simple and common to most jet engines: throttle to IDLE and wait. If after five seconds the warning was still on, you shut down the engine and wait for a further 30 seconds. The Phantom did not have a fire extinguisher and so, if the warning remained on after 30 seconds, the drill stated: "If fire confirmed...EJECT"

The 30 seconds came and went, and the warning stayed on. As we were not sure whether we were on fire or not, and I recognised the aircraft was still flying normally, I decided we could delay our ejection decision and we circled the airfield for a couple of minutes looking for confirmatory signs. Neither of us was keen on ejection, as the risk of death or injury was significant from landing in a

"A few seconds later my attention was drawn to a large red caption which appeared on the left side of the instrument panel. It said 'FIRE'."

45 kt wind or from going into the sea and being dragged by the parachute. I had considered and rejected landing because the runways were far too short for us.

The FIRE light stayed on, but we elected to divert 120 nm to the nearest suitable airfield. During the transit, the caption went out and then reappeared, which was a cause for concern. But the aircraft was still behaving normally. We found later that a partially contained engine failure had damaged the fire detection system, hence the warning.

So, what has this 'war story' got to do with resilience? As you might imagine, there was a little bit of adrenaline running about at the time, and while the event was attention-getting, there was nothing that might today be recognised as startle or surprise. I have a distinct memory of looking at a very bright red caption and thinking, *"Oh, and this isn't the simulator…"*. And then all that simulator training kicked in and we treated it like a simulation.

We both knew exactly what we each needed to do because the scenario was entirely familiar. As a junior pilot at the time, I was in the simulator twice per month for an hour and it was that training that carried us through. Handling the aircraft and its systems was second nature, and we both had spare capacity to think about our situation. Without discussion, we had both tightened our seat straps and mentally rehearsed the ejection drill while the clock ticked down 30 seconds.

There was plenty of other training to be had on the front line. The Cold War was in full swing and there were exercises to ensure we were ready to respond to whatever was thrown at us. The hooter and a backup telephone cascade system would summon us all to work, almost always at unsocial hours, and we would be expected to generate armed and crewed aircraft against a fixed timeline. Sometimes this could even culminate in a live missile firing against a towed target.

Exercises would usually involve 'ground play' where the directing staff (known as 'umpires') would inject stressors into the system such as intruders, injuries, suspicious packages, fuel contamination, or supply or armament defects – all simulated but all designed to find weak spots in the organisation and its training. The umpires increased the level of complication until people began to struggle. If you tried to bluff your way out of things, they would know. This was why I once ended up loading an 85 kg Sidewinder missile onto a head-height weapons rail for the first time (not my job) while wearing full chemical warfare gear. It was not my finest moment.

> "Neither of us was keen on ejection, as the risk of death or injury was significant from landing in a 45 kt wind or from going into the sea and being dragged by the parachute."

While I did not recognise it at the time, the process I was put through as a junior commander on exercises was not just to prove the system, but to train me so that I was able to handle whatever difficulties came my way.

My Personal "Day from Hell"

In the event, the live test was to come in January 1999 with my personal "day from hell". I was standing in as the commander of an RAF main operating base in Lincolnshire when I took a call from the NATO ops centre at Vicenza wanting to know why we had not returned to Aviano AFB (Italy) from our operational pause. It seemed nobody had told us we were required back in theatre, and Kosovo conflict ops were imminent. I kicked off the process of producing three E-3D (AWACS) aircraft and four combat-ready crews, and sending them to Aviano: *"Today would be good."*

About 30 minutes later, the local radio station reported a mid-air collision involving a fast jet, so I returned to the ops room. Information was sparse but it quickly became apparent that two aircraft were down, there was scattered wreckage, there had been loss of life, and we were the closest unit.

After a couple of calls to coordinate and confirm actions, I brought the ops room to silence and then spoke just six words: *"Action the crash and disaster plan."* The ops officer promptly broadcast the message to the whole unit on the PA and a well-rehearsed, complex plan began to swing into action. Over the next few hours, many decisions were needed, especially where the plan and reality did not quite align and where the parallel aircraft generation and crash response activities conflicted.

With all this in progress, I was told that RAF Brize Norton, our main air transport hub, had gone down in fog and there would be up to 6 VC10s coming our way. A little later, I heard one of the new arrivals had been involved in a taxiway excursion and was up to its nose axle in mud. In the subsequent hour, I had several calls about its recovery from angry people, including one from a pilot who was also suggesting it was our fault for not providing a marshaller and for sending him down a narrow taxiway. All were politely advised that we were working at full stretch and the VC10 was currently No. 3 on the priority list. I may have said something extra to the VC10 pilot, but memory fails me on its content!

By mid-afternoon there were still plenty of balls being juggled so I called a 'How goes it?' leadership group meeting. We were just discussing arrangements to support the inbound inquiry team when the PA went off: *"Fire! Fire! Fire! A fire has been reported in the air electronics building."* I ended the silence by demanding to see the exercise umpire. *"Bring him in here now. This is getting ridiculous!"* That broke the tension and meant that people simply treated the new situation as another twist in the scenario, even though there was no umpire, and it was very definitely for real. A bit of humour can help when people are under pressure.

There were many other tasks for me during the remainder of that 18-hour day, during which I barely had time to grab a coffee, never mind eat. I remember taking a very cheerful and clearly excited young photographer to one side before he went out to record the crash site. I explained to him gently that what he would be seeing would

not be pretty or pleasant, and then ensured there would be some pastoral care awaiting him on his return. I cannot unsee his photographs and I don't suppose he can either.

In the final analysis, we coped. The plans worked, though there were plenty of lessons learned and changes made – simple steps such as insisting on separate ringtones to distinguish between incoming callers, so that the on-scene commander could get through when required. And while it seems obvious with hindsight, deploying female staff to a field site means you need to provide access to appropriate toilet facilities.

Training for Resilience

On the resilience side, people were pushed hard but they got through it, aided by the plans and their personal training. In fact, they all stepped up a gear, further evidence that there is no substitute for reality. But be in no doubt that a combination of training and planning is the only route to dealing successfully with real challenges.

"A combination of training and planning is the only route to dealing successfully with real challenges."

I took it as both a compliment and a lesson when, after the post-op review, one of the ops officers told me that they could not believe how calm I was throughout, and that it had calmed them down too. I may have looked and sounded calm, but I might not always have felt it! The lesson was that calmness is 'infectious' and that it spreads. On the other hand, so does panic.

Key to remaining calm is to control your breathing; the advice to 'take a deep breath' is sound. If you simply regulate your breathing, your own internal biofeedback mechanisms will help you by reducing the levels of stress hormones in your system. It works, try it next time you feel under pressure.

Train Home

The Phantom fire and diversion had one last test for us. After a night stop at RAF Lossiemouth, we were ordered back to base by rail and the journey included changing trains at Aberdeen. We had only our flight gear, so were stood on the platform in our immersion suits, wearing our life jackets and carrying our helmets. It was an interesting 30 minutes. It seemed most of the North Sea's oil rig workers had spent their off-shift morning filling themselves with beer before popping down to the station to see what was going on and making helpful and witty remarks such as *"Eh, pal, you've lost your jet!"* If you ever want to experience real stress, try being the unwilling star of an impromptu pop-up comedy routine…

See the talk!

CANSO/EUROCONTROL Global Resilience Summit (from 13m30s)

https://www.eurocontrol.int/event/canso-eurocontrol-global-resilience-summit-2021

Air Commodore Dai Whittingham became Chief Executive of the UK Flight Safety Committee in 2012 after a full career as a pilot in the RAF. He is active in a range of safety bodies including the EASA HF and CAT analysis groups, and he is Vice-chair of the European Advisory Committee for the Flight Safety Foundation.

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THREE APPROACHES, TWO GO AROUNDS, AND ONE DIVERSION

A surprise in the air often means surprise on the ground, but controllers and pilots rarely have the chance to share perspectives. In this article, **Eric Carter** and **James Norman** present a case study to highlight the benefit of a collaborative voice.

KEY POINTS

- **Rare runway configurations, aircraft warnings, and ATC instructions can compound to surprise both pilots and controllers.**
- **ATC works to mitigate surprises by using predictive continuity with flight operations.**
- **Learning from surprises is crucial in a safety management system.**
- **In the open-source era, don't be surprised if your work is recorded and distributed.**

Flight Deck Perspective

"Terrain, terrain…whoop whoop…pull up!"

They say that being a pilot is hours of boredom punctuated by seconds of terror. This was one of those moments.

Rewind 30 minutes. In our Boeing 767, the captain and I were beginning to plan our arrival and landing into San Francisco after an otherwise routine transcontinental flight originating in New York's JFK airport, in December 2021.

The ATIS (automatic terminal information service) provided our first surprise of the evening: due to rare easterly winds, SFO was landing to the east on 10L. (A pilot could spend their entire career flying into SFO and never land on the '10s'.) As an added bonus, the runway only had a non-precision approach.

After a through briefing, we began vectoring via left traffic. We made sure to have our terrain awareness system up on our flight displays; unlike the usual SFO approaches to the 28s, this was a 'black hole' approach over unfamiliar mountainous terrain.

On speed and configuration, we were seconds away from the 1000 ft "cleared to land" callout, when the airplane blared *"Terrain, terrain!"* – a warning most pilots only ever hear in the simulator. Although our aircraft was stabilised and being flown as per standard operating procedure (SOP), we are trained to honour any type of system caution or warning. We know that 'plan continuation bias' (the tendency to continue with an original course of action that is no longer viable) only increases as we near a goal – in this case the runway. It sometimes takes a highly salient cue such as a loud alert to snap us out of our routine.

My early pilot instructors taught me to think of a go around as the expected outcome of an approach. This might help to mitigate unwanted effects of surprise, perhaps even the startle effect, as we are primed more effectively if actually called upon to conduct the manoeuvre.

Despite the well-laid plan, there is usually something askew each time we perform a go around. This time it was our next surprise: "Fly the *published* missed approach." In a matter of seconds, the workload was multiplying due to (1) a rare approach, (2) a rare (dire) warning, and (3) an ATC instruction that was usually only heard in the simulator.

"We were seconds away from the 1000 ft "cleared to land" callout, when the airplane blared *"Terrain, terrain!"* – a warning most pilots only ever hear in the simulator."

It is important to note here that most approaches are visual approaches. Per U.S. regulations, a visual approach is not a standard instrument approach procedure and has no missed approach segment. Tower will issue a heading and altitude. During instrument approaches, many facilities will often issue a heading and altitude in the event of a missed approach. There is no requirement for a controller to issue a "published missed approach" in the U.S. during an instrument approach.

After brief troubleshooting, my colleague and I figured that the warning must have been spurious and decided to try again. ATC queried us more than once for the reason for the go around, which we replied with a stoic *"standby."* Aviate, navigate, communicate.

Our second approach was a carbon copy of the first, except we were now making right traffic. To our amazement, once again at 1100 feet we received a *"Terrain, terrain, pull up, pull up"* warning! And once again, we did another go around.

We concluded that trying a third time would probably yield the same result, and elected to divert to Oakland where terrain would hardly be a factor. ATC was gracious and accommodated our request quickly. And as it turned out, many of our passengers lived in Oakland, so this divert actually saved them an expensive cab ride across the Bay Bridge!

What caused the terrain warnings in this event? To this day, we are unsure. Possibilities include an anomaly in the terrain database, the design of the non-precision approach, or 5G.

But now the biggest surprise of all. One month after our event, a member of the public made a YouTube video of our event, combining the ATC audio tapes and the live ground track from ADS-B. In a matter of days, the video was getting tens of thousands of hits, and was being shared all over aviation social media. Imagine your surprise to wake up one day to dozens of text messages saying, *"you're famous!"* Not fun.

But the story gets even stranger. In the previous issue of *HindSight*, I (James Norman) contributed an article titled *De-risking FOQA: Flight Data Management and Pilot Protection in an ADS-B World*. I explored the consequences of our increasingly open-source world of flight data, and posited the consequences of 'pseudo' flight data tethered to ATC 'tapes'. Now that hypothetical scenario was playing out with the person who wrote the article!

Needless to say, this event has been incredibly educational for me, both for the experience as a pilot and also for the opportunity *HindSight* magazine has provided to share frontline stories, as well as raise awareness of cutting-edge issues like the rise of open-source data and the new world we live in.

"One month after our event, a member of the public made a YouTube video of our event. In a matter of days, the video was getting tens of thousands of hits."

San Francisco Tower Perspective

As a 32-year veteran air traffic controller throughout medium and large facilities in the US, there isn't much I haven't seen. A windy stormy day causing a B777 to fly like it is in the hand of a child dreaming of flight, stands out.

For SFO tower, landing on the '10s' is an extraordinarily rare event – perhaps only used a few hours each year. Departing runways 1L/1R and landing runways 28L/28R is by far the most prevalent, with combined departing and landing runways 28L/28R. Typically, during the winter, we are departing runways 10L/R, landing runways 19L/R, and when the wind picks up departing and landing runways 19L/19R.

Go arounds can be surprising to flight crews, and they can be surprising to controllers as well. At SFO, we must manage one of the most challenging runway configurations in the country: parallel intersecting runways, all four of which can be active. To manage this challenge, we train by working from the intersection out. This means that the intersecting runway is always the main focus, and workload prioritisation determines the sequence of events and transmissions from there. Add an unexpected go around, and the temperature rises very quickly,

Because of this, one of my missions is to make life easier for both controllers and pilots. In my role as a leader and mentor, it is important to help my controllers better understand both sides of the mic. That is why I have promoted the use of "fly the published missed" at my facility. While heading/altitude is the norm at most other facilities, I believe the published missed is more predictable and more easily managed for both pilots and controllers. With the "published missed", a flight crew has a fighting chance to perform as they actually train. Once they "communicate" we can work on the "aviate" and "navigate" – a reset, of sorts. Of course, there are going to be times that this is just not possible, but that should not be the norm.

When I listened to this event, I was heartened to hear the younger controller issue the published missed to the crew. The takeaway for us was

that learning happens both formally and informally, and the relationships and positive collaborative culture I have promoted in the facility over the years came to fruition in this event when the controller took the lead and issued the published missed. Another 'pleasant surprise' for ATC is that, in this case, assigning a heading and altitude could result in a terrain loss, because the minimum vectoring altitude (MVA) is well above the aircraft's position when calling their go around.

For us, surprises can take many forms: technology, weather, NOTAMs, the list goes on. That's why I believe documenting them is so important. As part of our Voluntary Safety Reporting Program, we have aligned our program with the pilots' ASAP program. This is called the Confidential Information Sharing Program (CISP). CISP allows air traffic controllers' safety reports to be shared with pilots' reports. When each side reviews an event, there are so many opportunities to learn. Handling surprises in the heat of the moment is one thing, but having a data repository where we can start to track and see trends is what allows us to operate in a successful safety management system. And by disseminating these reported issues via 'lessons learned' discussion sheets to the frontline controllers and pilots, hopefully one person's surprise turns into the next person's "I read about that!".

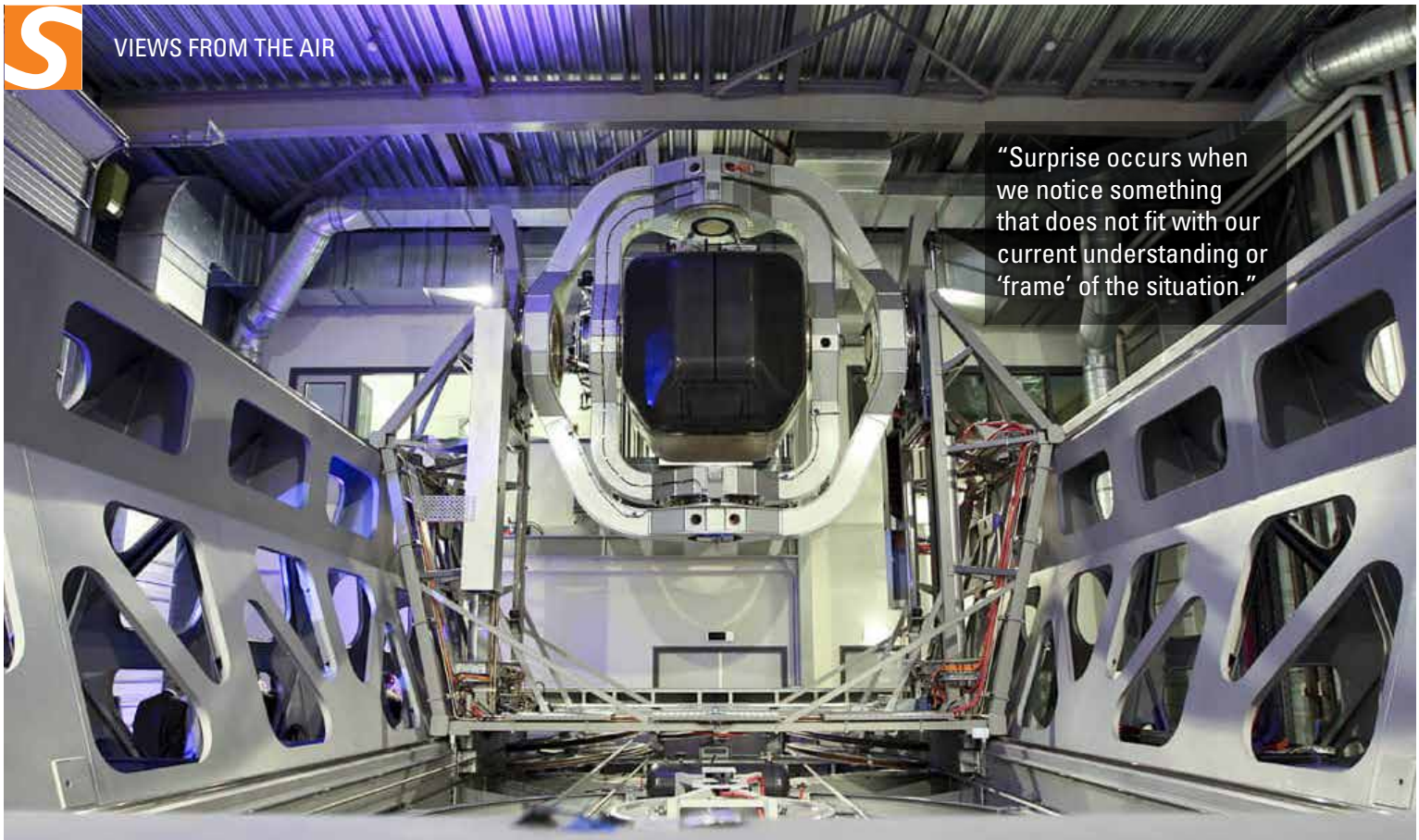
Takeaways

From the pilot and controller perspective, the most important takeaway here has been in our collaborative effort. Both pilots and controllers inhabit workspaces that are tightly coupled, yet provide little opportunity for dialogue and discussion of events after-the-fact. We were able to use this event as a case study recently at a large aviation safety conference to highlight the benefit of collaborative voice. With the increasing use of CPDLC and datalink, we believe that the relationship between controllers and pilots will only unfortunately continue to become more separated. Hopefully both sides of the mic can find a space to maintain this dialogue in the future. Kudos to *HindSight* for promoting this important effort!

Eric Carter is an air traffic controller at San Francisco Tower. Since 1990, Eric has been proactive in safety at the facility, regional, and national levels, as well as in the Voluntary Safety Reporting Program (VSRP). Eric most enjoys being able to use his expertise to close the information gap between controllers and pilots, particularly as it relates to technology and training.

James Norman is a B757/767 pilot and FOQA gatekeeper for a US airline. He also teaches safety leadership and risk management on behalf of the Air Line Pilots Association (ALPA). He is a Ph.D. Candidate at the University of North Dakota, and his dissertation research focuses on voluntary reporting culture in commercial aviation. He resides in Minnesota with his wife and twin daughters.

"For us, surprises can take many forms: technology, weather, NOTAMs, the list goes on. That's why I believe documenting them is so important."



"Surprise occurs when we notice something that does not fit with our current understanding or 'frame' of the situation."

KEEP CALM AND REFRAME: ESSENTIAL ELEMENTS OF DEALING WITH SURPRISE

Over recent years, research in the Netherlands has helped to understand the nature of surprise in the flight deck, and has evaluated interventions to help pilots to respond in the best way possible. In this article, **Annemarie Landman**, **Eric Groen**, **René van Paassen**, and **Max Mulder** outline some of their key findings and insights on training and the management of surprise.

KEY POINTS

- **Surprise is a natural trigger to adjust one's understanding or mental 'frame' to the current situation, but such 'reframing' can be severely impaired under stress.**
- **A minor surprise can already significantly impact pilot performance, eliciting responses which are guided by reflexes rather than analysis of the situation.**
- **Unpredictable, variable, and explorative training can help build a proper repertoire of frames and skills that are resilient to surprise.**
- **Self-regulatory methods, such as surprise-management procedures, can help with 'recovering' one's brain after a surprise.**

Surprise occurs when we realise that our view of the situation turns out to have been erroneous, often leading to a reappraisal of past events to regain a consistent view. Surprise has been identified as an important contributing factor to loss of control in-flight (LOC-I) events, as it may impair or delay a crew's adequate response to maintain control of the aircraft. A surprise involving a sudden threat signal will cause stress, in which case a possible response is also commonly assocated with what is known as

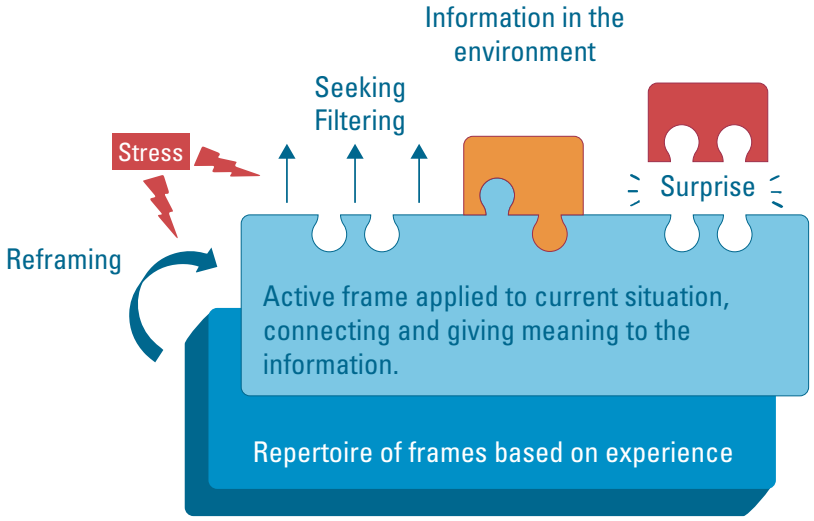


Figure 1. Schematic representation of the 'reframing model', showing that surprise arises when a piece of information (illustrated by the red puzzle piece) does not match the active frame.

'startle'. Aviation safety authorities have issued recommendations to take surprise into account in flight crew training. A joint research team of the Faculty of Aerospace Engineering of Delft University of Technology, and the Human Performance department of TNO (both located in the Netherlands) investigated the effectiveness of various training interventions aimed at improving pilots' abilities to deal with surprise. In this article, we share the most interesting findings, hoping that these provide useful insights to those working in any domain where surprise management is important.

Conceptual Model of Surprise

We created a conceptual model (Landman, et al, 2017a) to illustrate what happens in the brain when one encounters a surprising situation that is also stressful. A simplified version of the model is depicted in Figure 1. It uses 'frames', where a frame can be seen as a coherent set of expectations, rules and responses applicable in a certain context. Surprise occurs when we notice something that does not fit with our current understanding or 'frame' of the situation. Based on past experience, we have built a repertoire of frames of how things ought to work and what we can expect to happen next. These frames allow us to focus directly on what is important (i.e., attain situation awareness), make judgments, and select appropriate responses. Receiving information that does not fit the prediction from the current frame should trigger surprise: an alarm which signals that there may be a problem with our frame. We may need to adjust our frame (i.e., 'reframe') by collecting additional information and combining this with what we know (i.e., our repertoire of frames).

Reframing can be difficult by itself, but it is even more difficult under stress. Stress impairs the guidance of attention that frames provide (the 'seeking and filtering' in Figure 1), so that we can become more or less 'frameless'. We may start to misinterpret or completely miss relevant cues that would be very clear to us when interpreted within the proper frame. It can suddenly become more difficult to see things in context, to set proper priorities, and to focus on what is important. Such cognitive issues may result in haphazard actions or indecisiveness, the latter being known as 'freezing' in common language. The failure to meaningfully integrate incoming information in a frame further increases stress, which further hampers reframing. This means that our brain can become caught in a downward spiral, which can be labelled as a 'brain stall'. Our research focuses on the interaction of stress and reframing, to find ways that may help pilots 'recover' their brain.

"Introducing unpredictability and variability into training can improve pilots' reframing skills, and help them better manage surprising events."

Effect of Surprise on Stall Recovery

In a simulator study (Landman, 2017b) we validated the conceptual model by investigating how pilots respond to a surprising event in terms of stress and behaviour. Twenty commercial pilots practised recovery from an aerodynamic stall on a medium-sized twin jet in the moving-base Desdemona simulator (see photo on page 44). After the training session, they were exposed to a test, which included one unanticipated (surprising) stall, and one announced (unsurprising) stall, both at low altitude. Although the surprising stall was still likely much less surprising than a similar event would be in reality, we already observed some interesting changes in pilot behaviour. Generally, the pilots were less likely to apply pitch trim, and were more focused on rolling wings level in the surprising stall, which sometimes led to pilot-induced oscillations when the airspeed was still too low for the ailerons to be effective (Figure 2). The surprising stall was also rated as more mentally demanding than the anticipated stall, possibly due to the extra effort required for reframing. There was no difference in experienced stress, which was likely due to the safety of the simulated setting.

Building Experience Through Unpredictability, Variation and Exploration

Given that even moderate changes in expectation affect selection of the correct frame and performance in surprise situations, how can we prepare pilots for surprises? In a further study (Landman, 2018), we found that introducing unpredictability and variability into training can improve pilots' reframing skills, and help them better manage surprising events. Ten commercial pilots trained a series of manual flight scenarios with controllability issues in a variable order, in various contexts, and without information on the scenario. Ten other pilots (the control group) trained the same scenarios, but in a structured order, in the same context, and with information on the type of scenario trained. When both pilot groups were confronted with a problem that required the application of previously

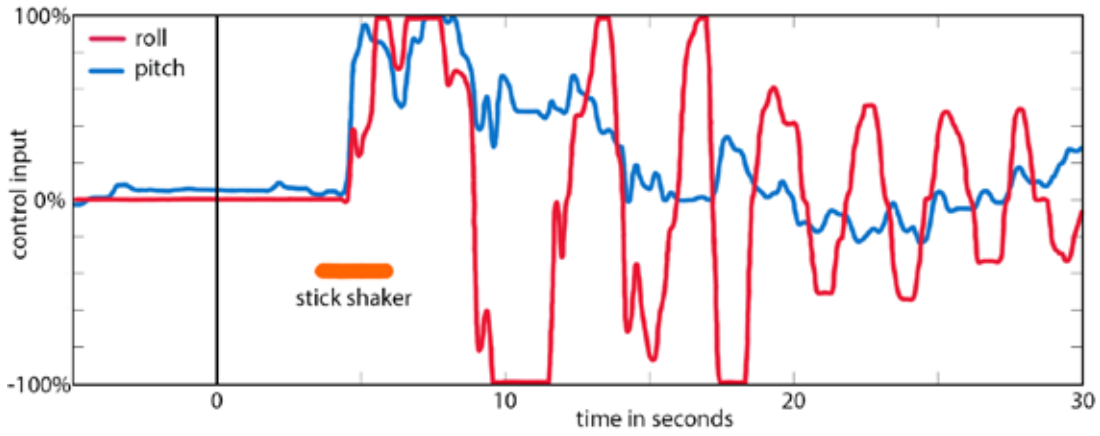


Figure 2. This plot shows the roll oscillations (red line) induced by a surprised pilot in response to an unanticipated stall warning.

learned skills in a new manner, pilots who had received the variable and unpredictable training outperformed the control group. This finding underlines the hypothesis that we construct the best frames when we experience situations with variations which are also surprising. When events are too consistently trained in the same context, or in the same combinations, we may develop a limited, 'rigid' frame for these events. This may cause confusion when the events occur in a divergent manner.

"Exploratory training can optimise a pilot's understanding of autopilot logic."

In a further study, which is to be published, we demonstrate that exploratory training can optimise a pilot's understanding of autopilot logic. In exploratory training, one learns new information by trying out different potential solutions to problems. We gave 45 general aviation pilots a theoretical course on autopilot functions, and then trained them in a Piper Seneca model in the Simona simulator (Figure 3). In this simulator session, different autopilot failures were introduced, and for each failure, the pilots were asked to try to select the highest functioning level modes of automation (i.e., giving the most guidance). During the training phase, pilots in a non-exploratory (control) group were told about these failures and corresponding solutions in advance, whereas the pilots in an exploratory group had to figure out the solutions by themselves. Both groups were told the correct solutions after each exercise. In a subsequent test containing new, surprising failures, the exploratory group was significantly quicker in finding the solutions. This suggests that proper frames can best be built through exploration and problem-solving, and that such training may benefit pilots when they encounter surprising situations.

Self-management of Surprise

To see whether awareness of reframing helps, and self-management of surprise is possible, we investigated the effectiveness of a checklist-based method (Landman, et al., 2020). This method is inspired by the unofficial 'resetting the clock' procedure, which was previously used by US Navy pilots (Croucher, 2008). This quick, goal-directed action was meant to prevent hasty responses and induce a sense of control. Thinking along similar lines, we

Figure 3. The Simona research simulator at Delft University of Technology.

hypothesised that a simple memory-item checklist can provide pilots with a tool to 'recover' their brain during surprise.

In our study, we trained pilots to use a four-item checklist, COOL: Calm down, Observe, Outline, Lead. We found that pilots liked the method, remembered to apply it in surprising situations, and showed better decision-making in some situations when compared to pilots who were not trained with this method. However, it also induced some counterproductive workload, and sometimes seemed to interfere with the prioritisation of issues that should take precedence over the COOL checklist.

"A brain recovery method should at least include an item of stress management as well as an item of observing the general situation to collect information and prevent hasty response."

Based on the pilots' feedback, we concluded that a brain recovery method should at least include an item of stress management (e.g., by taking a deep breath, such as 'tactical breathing' as it is called in the military), as well as an item of observing the general situation to collect information and prevent hasty responses. We are currently investigating an adapted checklist (ABC – Aviate, Breathe, Check), which is shorter and should help pilots prioritise their actions better.

Conclusion

The key problem with surprising events in stressful situations is that under stress the brain cannot access (or is unaware of) the appropriate mental frame needed to make sense of the situation. Our research has shown that training interventions, such as adding variability, unpredictability and exploratory training can improve one's sensemaking skills. In addition, we showed that a simple memory-item procedure, which includes an item of stress management, can help pilots to cope with surprising events and prioritise their responses. We are currently applying our knowledge, for instance, to investigate the effect of surprises caused by spatial disorientation, and to identify inadvertently counterproductive ways of training for surprising events (i.e., negative transfer of training).

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Assoc. Prof. René van Paassen, PhD, is an associate professor in Aerospace Engineering at Delft University of Technology, working on human machine interaction and aircraft simulation. His work on human-machine interaction ranges from studies of perceptual processes, haptics and haptic interfaces and human manual control, to the design of and interaction with complex cognitive systems, applying cognitive systems engineering and ecological interface design for vehicle control.

Prof. Max Mulder, PhD, is full professor 'aerospace human-machine systems' at the faculty of Aerospace Engineering, Delft University of Technology. He leads the section 'Control and Simulation' which investigates reaching higher levels of automation in aviation.

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"In a complex and dynamic environment, the human is the strongest link, possessing the flexibility and creativity to deal with unforeseen events."

TRAINING FOR SURPRISES

RESEARCH AND IMPLEMENTATION

Training is a critical part of dealing with surprises in the flight deck. **Jeroen van Rooij** and **Edzard Boland** report on a research project by NLR and KLM to develop training to help pilots to maximise performance in every unexpected situation.

KEY POINTS

- **In a research project funded by EASA, the Royal Dutch Aerospace Centre NLR and Royal Dutch Airlines KLM developed, evaluated and implemented pilot training for the recovery of surprise effects.**
- **The goal was to develop a training programme helping pilots to develop knowledge, skills and attitudes usable in every unexpected situation to maximise performance.**
- **Part of the training is a recovery technique. This technique (ROC; Relax, Observe, Confirm) is relatively simple. However, a thorough training and implementation plan for application of the technique in unexpected situations is needed.**
- **Feedback from pilots after the training and after actual application during simulator sessions or operational flight has been positive.**

Even in a highly standardised commercial aviation world, unexpected events are a fact of daily life. Mostly, these cause just a minor distraction, but sometimes they have significant detrimental effects on crew performance. In the aftermath of the Air France 447 and ColganAir 3407 accidents, EASA instigated research on the impact of startle and surprise on pilots, and developed potential training interventions. In this research project (EASA, 2018), the NLR and KLM developed and evaluated pilot training on the recovery of startle and surprise effects, which could also be of use for cabin crew, ATC and other (non-aviation) domains. By combining the NLR, a research institute, with KLM, it was possible to develop a scientifically based and practically implementable training intervention.

Several incidents and accidents in the past couple of decades, such as the

ones mentioned above, have taught the industry that in complex and dynamic situations, pilots cannot rely solely on procedures, rules, and automation. Different approaches have been suggested on how to manage such situations. One of those approaches is a shift from proceduralised, task-based training to a more competency-based approach using a wide variety of training scenarios (see Landman, et al, 2017). The aim is to provide pilots with knowledge, skills and attitudes that can be applied broadly. This resonates with the Safety-II idea that in a complex and dynamic environment, the human is the strongest link, possessing the flexibility and creativity to deal with unforeseen events. The assumption, however, is a normally-functioning individual. The effects of startle and surprise can seriously impair normal functioning. As surprise is much more common than startle, the research focused on the former.

Surprise Effects

Surprise refers to a mismatch between expectations and reality and can have multiple effects. Among these are physiological effects such as increased heart rate and blood pressure and inhibited fine motor skills, cognitive

"Crews are trained very well to expect surprises in the simulator. That and the fact there is no real danger, does not result in strong surprise effects."

effects such as narrowing of attention and impairment of working memory, and emotional effects such as confusion and fear. All these effects, especially combined, can create a sense of urgency to take action, which in some cases may be associated with the 'fight or flight' response. This can have significant negative consequences on the decision-making process, possibly leading to rushed or wrong decisions.

For the pilot, and for any operator in highly dynamic and safety critical situations, it is paramount to recover from these negative effects as soon as possible to be able to apply all competencies, maximising performance. Therefore, the research team focused on a strategy to manage the effects of surprise: Relax, Observe, Confirm (the situation).

Relax

In cooperation with a performance psychologist, techniques already in use in other domains (such as sports and the military) were scrutinised for practical use in an airline cockpit. As a result, the team evaluated if the following techniques could be beneficial to overcome the effects of surprise:

- taking physical distance (pushing and consciously feeling one's back in the chair),
- a simple breathing technique, and
- muscle relaxation.

Instead of the old slogan 'stay calm', an active way of controlling emotional and physical effects was chosen, thereby shifting the focus from the situation towards the body. The hypotheses were that this 1) reduces the chance of aggravating the situation by making rushed decisions or inputs to the aircraft, and 2) enables the pilot to perform at their best by reducing stress.

The next step in the strategy is intended to make full use of the potential of a multi-crew flight deck by introducing a check on the mental state of the colleague. Surprise affects individuals differently depending on the level of fatigue, different mental models, or previous experiences. This can create a 'split cockpit' where two individuals work in isolation instead of together. A complete 'Relax' takes five to ten seconds, surprisingly similar to the (aviation) saying, *"sometimes it is better to count to ten before taking action."*

Observe and Confirm

After managing surprise effects, a proper decision-making process can be initiated. Many current decision-making tools begin with observing the facts and communicating them. The aim was to use this step to start up the cognitive process in an easy way and to provide another barrier to rushed decision-making and/or action taking. No decisions are made – only observations have to be called out. Finally, the cognitively more demanding steps of confirming the situation and the regular decision-making process steps, such as risk assessment and option generation, are taken.

To summarise, the purpose of the strategy is fourfold:

- controlling physiological and emotional reactions
- being 'fail safe', i.e., not making things worse
- ensuring maximum team performance (preventing split cockpit), and
- connection with current (decision-making) practices.

Experiments

The experimental training had a setup of 1:30 hr classroom briefing time and 1:30 hr simulator time. It was designed to be an initial training which requires a follow-up recurrent training to secure transfer of training to the live environment.

In an introductory letter, the participating pilots were asked to think about a surprising event in their flying career, so this could be discussed during the briefing, but also to give practical relevance to the training. Specifically, time was spent on personal surprise effects, to be used as a future trigger to apply ROC. After some theoretical surprise background, the techniques described above were explained and practised by following instructions and in a visualisation exercise (also known as 'chair flying'). An important part of the classroom sessions was to normalise the emotional and physiological effect from surprise. These are very normal human reactions to an abnormal situation.

A total of 44 active airline pilots were trained in a simulator to practise the surprise recovery techniques – not aimed at one specific surprise, but at any surprise (technical, ATC, meteorological, crew- or self-induced, etc.). The message to the crews before going into the simulator was somewhat surprising to some of them: *"We are not going to surprise you."* (At least, not in the same way the real-life example did that crews provided in the classroom session.) Crews are trained very well to

expect surprises in the simulator. That and the fact there is no real danger, does not result in strong surprise effects. The only requirement given to the crews was to practise the ROC every time one of them thought it would be helpful in a real-life situation.

The first training result that can be measured is participant reactions, and in this case the participating pilots were very enthusiastic. They indicated the techniques helped them to control their emotions and they intended to use the techniques in real life situations. They also mentioned they felt better prepared for unexpected situations (and literature indicates that confidence helps to dampen the effects of surprise). The researchers observed that the pilots were able to learn and apply the techniques during this initial training. These observations confirmed that the techniques influenced their information gathering. Instead of rushing to conclusions, pilots who used the techniques verbalised the information cues (the 'observe' step) before analysing it (the 'confirm' step). For the research team, this was an indication that the techniques have a beneficial effect on the decision-making process.

Implementation

After these encouraging results, KLM chose to implement startle and surprise training by setting up a core team. A few changes were made to the experiment setup to connect seamlessly with the current procedures and training practices.

To summarise: an electronic briefing package (iBook) was sent to the pilots before receiving training, the briefing time was reduced to 1 hour, a 360 video for VR goggles was made to practise the techniques, and simulator time was extended to 1 hour and 50 minutes. The strategy was rephrased in a single word: 'Reset'.

The implementation started by training the new instructors by the core team. This was to 1) standardise and provide a deep understanding of the theory and the technique, and 2) to stimulate enthusiasm about the potential benefits of the training. There was concern about whether pilots would be open for the breathing technique and muscle relaxation, so well-informed and enthusiastic instructors were deemed a key success factor. The core team stressed the fact that these techniques were not becoming part of standard operating procedure, but a tool for every pilot, to be used at their own discretion.

After this thorough train the trainer process, all KLM pilots received their initial startle and surprise training, with a follow-up six months later, during regular simulator sessions. Like the experiment pilots, the feedback from the majority indicated they felt better prepared for unexpected situations. The pilot core turned out to have an open mind towards the training ideas, as the majority indicated that they were planning to use the 'Reset' to handle real-life surprises. Later on, in incident investigations, multiple crew testimonies were received indicating they used the 'Reset' when handling the situation and they believed it improved their performance.

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Edzard Boland has an MSc in Aviation Human Factors and worked with the Royal Netherlands Air Force from 2005 as an Aviation Psychologist. In 2008 he moved to the NLR as a training specialist. Since 2016, he has supported airlines with the introduction of Startle and Surprise training. In 2019, he started working one day a week as a reserve officer for the Royal Netherlands Air Force as an accident investigator.

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SURPRISES AND SURVIVAL: LIFEBOATS AND LEARNING

Lifeboat crews have saved hundreds of thousands of lives worldwide, and for many of these events survival depends on how crews handle surprises. **Adrian Woolrich-Burt**, a former B737-800 Captain and current Lifeboat Commander, recounts one such event, and the implications for human performance.

The launch bell rang just after 10:00 in the morning. Daily boat checks were complete and the duty crew were sitting down to their second, and probably favourite breakfast of the day. The Coastguard Watch Officer at the other end of the red telephone requested the lifeboat assist a team from London Fire Brigade recover a person stuck in the mud on the foreshore. This is a routine call for any of the four Royal National Lifeboat Institution (RNLI) lifeboat stations on the River Thames between Teddington and the sea in England.

The situation that the crew encountered when they arrived on scene was significantly different to what was expected. The casualty was not in the mud. He was immersed in 15 metres of fast-flowing water and attempting to end his own life by drowning. Shouts from the skipper of a nearby workboat

indicated that there was another person in the water who – seconds before – had disappeared under the surface, and not re-emerged.

"Time pressure, previously framed by how many hours before the tide reached the mud, immediately compressed into how many seconds before the casualty suffered a hypoxic cardiac arrest."

The crew's mental workload increased rapidly. What had been briefed en route as a relatively low stress supporting role changed in an instant. Time pressure, previously framed by how many hours before the tide reached the mud, immediately compressed into how many seconds before the casualty suffered a hypoxic cardiac arrest.

The casualty trying to end his own life needed to be assisted, but getting close in a powerful lifeboat without causing harm had to be risk assessed, briefed, and carried out with care. The tidal flow, river conditions, water temperature, rescue plan, and allocation of tasks had to be considered, checked, and implemented in a short time. The Thames is the UK's busiest river, and traffic had to be stopped in both directions. The physical workload increased too. Removing a person from fast-flowing water can be a challenge, especially when wearing a thermal dry suit, face mask, and helmet. To do it safely and speedily requires strength and effort from all the crew. Removing two casualties halves the available space, and more than doubles the workload.

The extraction plan also had to be revised. A conscious person stuck in the mud could probably be walked out on fire service load spreaders, but recovering an unconscious casualty with a stretcher may interrupt effective CPR and prove fatally slow. In this instance, it was better to arrange to meet an ambulance at a nearby jetty or wharf. However, there are hundreds to choose from on the Thames, and those easily accessible by lifeboat may be impossible to access by road. Considering the direction from which an ambulance will arrive would cut down transit time and improve the casualty's chance of survival. Getting the ambulance moving towards the casualty even before their removal from the water had taken place would improve survival chances further.

In this case, the person was recovered to the lifeboat, given medical attention, and handed over to the London Ambulance Service at a nearby causeway. This was a life saved.

Training

The fact that the crew on the Thames that day was able to absorb the pressure and react to a radically different situation in a coherent and co-ordinated way did not come about by chance. The Institution's training and assessment environment prepare crews for these challenges from the first day of their induction.

Photo: RNLI/Nathan Williams

The unofficial motto of the RNLI is 'With courage nothing is impossible'. To some extent that is true. Crews still need to have the courage, both physical and mental, to deal with all that maritime search and rescue may throw at them. But as in aviation and other safety-critical disciplines, we know that while courage may be necessary, it is not sufficient. It is only through a sophisticated package of non-technical (NOTECH) training that an otherwise disparate group of individuals – many of whom are volunteers – learn to function as a team greater than the sum of its parts.

Lifeboat crews are trained and assessed in leadership, teamwork, decision-making, and situational awareness. However, recent research has demonstrated how much the shock and startle effect can be a factor in crew performance.

"The fact that the crew on the Thames that day was able to absorb the pressure and react to a radically different situation in a coherent and co-ordinated way did not come about by chance."

Shock and startle can be the result of a kinetic event, such as the boat capsizing, or it can be the result of a rapid escalation of cognitive demand, such as in the rescue described above. In both cases the RNLI has found preparation to be the key.

Deliberately startling crews during training sessions is counterproductive. After all, few people can concentrate on a training scenario when they are trying to second-guess where the next explosion is coming from. It is more productive to develop a graduated programme to educate and expose crews to the feelings and emotions they might experience when they are suddenly confronted by a new challenge, or when their certainties are rapidly undermined. For lifeboat crews much of this is done at the RNLI College in Poole, and in particular in the cold-water tank in our Sea Survival Centre. Crews are required to step from high platforms, capsize operational lifeboats, and overturn life rafts in the dark.

The RNLI teaches crews to expect a physical response. Pulses quicken, breathing shallows, and muscles tense. Traditionally, these automatic responses were regarded as negative influences, ones that reduce performance and impair effective search and rescue. However, crews are now taught that these readily identifiable physical effects are tangible manifestations of other less obvious threats – tunnel vision, task fixation, decision inertia, and confusion. Helpfully, the presence of one indicates the likely presence of the other.

"While the operating environment may be very different, the parallels with aviation, especially on the flight deck, are noticeable."

Self-awareness is key to success. Crews are taught that when undergoing periods of high stress, they can expect to make simple arithmetical mistakes, become confused, and suffer cognitive dissonance or even disbelief. Some crew members will feel an overwhelming need to isolate themselves from the outside world. These are hidden dangers that creep up on the individual at the worst possible time, and we find the only effective countermeasure is to get crews to actively strengthen the team dynamic even more.

Collaboration for Survival

When stress levels rise, RNLI crews are expected to share their mental model, verify safety critical tasks, and check for gross errors. Taking a loud roll call when the crew have wedged their heads into a small air space under a capsized lifeboat can kick-start this process, as well as confirming that no-one is trapped. It is a high energy and purposely collaborative process that helps prevent panic. Importantly, it gets four or more highly stressed individuals back functioning as a team.

While the operating environment may be very different, the parallels with aviation, especially on the flight deck, are noticeable. In aircraft, small teams of mutually dependent individuals – flight and cabin crew – may be faced with a multitude of physical responses to sudden onset stress. Taking a loud roll call may not be a suitable response to an in-flight non-normal condition, but using a known physical response as an indicator that cognitive ability may be diminished could pay dividends.

The RNLI is a charity, but it also the UK and Ireland's principal maritime search and rescue asset. Operating state-of-the-art boats from 238 lifeboat stations, it provides 24-hour cover out to 100 nm offshore in all weathers, all day, every day, since 1824. The RNLI has saved more than 144,000 lives. It is something we are enormously proud of.

Adrian Woolrich-Burt is a RNLI Lifeboat Commander on the River Thames. Prior to this he flew as a B737-800 Captain with Jet2.com, and taught theoretical knowledge on the B737MAX for Boeing Flight Services. He holds MSc degrees from the University of London, and a Post Graduate Diploma from the London School of Economics.

HANDLING THE UNEXPECTED: A VASCULAR AND TRAUMA SURGEON'S PERSPECTIVE

The operating theatre, like the flight deck or control room, involves predictable work, but with unexpected moments that demand expertise from all team members. Trauma surgeon **Mark Edwards** emphasises the importance of experience in the operating theatre, illustrated with a hypothetical scenario.

KEY POINTS

- **We cannot predict when something unexpected will occur, but we know that we need to be ready for it and trained with this in mind.**
- **Time and exposure in the operating theatre are critical during surgical training. Thousands of new or unexpected events are encountered in the many years of surgical training that precede independent practice in surgery.**
- **Greater experience in practice increases understanding and cognitive skills, and blunts the stress response to novel circumstances.**
- **Being able to respond effectively to the unexpected requires training that focuses on the task, the team, and how we integrate the two.**

Anaesthetist: *"The blood pressure is dropping quickly now. I'm putting up the next bag of red blood cells. Call the transfusion team. We're going to need more."*

Surgeon 1: *"I can't see where the bleeding is coming from, but it's arterial… no wait, I can see it now, it's close to the left kidney. I've found it. There's an injury to the aorta."*

Surgeon 1 (to Surgeon 2 – trainee): *"Press firmly here over the aorta. OK, good, that's slowed it right down. OK, we've improved things, the bleeding from that injury has slowed."*

Anaesthetist: *"No change to the blood pressure yet, we've got more blood on the way from the lab, which the theatre runner has told me will be here in 3 minutes. I've just got one more unit of plasma left. I'm running a blood gas now. Oxygen saturations are lower now despite being on 100%."*

Surgeon 1: *"Acknowledged. Team, let's improve the lighting. Can you bring that overhead light to focus here? I'll take that retractor now. OK, give me slightly more view of the aorta above the kidney beneath the vein. Good, I can see it now. Let me have the aortic clamp."*

Surgeon 2: *"I think a second retractor would improve our view here."*

Surgeon 1: *"OK, good idea, let's get that there…better, I've got a good view of the aorta…clamp going on, now."*

Anaesthetist: *"No change here, blood pressure still low, pulse rate is still rising despite that plasma."*

Surgeon 1: *"Acknowledged. Let's take stock of where we are now that the bleeding is controlled. ABC: from the top…"*

Anaesthetist: *"A – Airway – secured, B – Breathing – those oxygen sats are much lower now and that gas shows marked hypoxia, C – Circulation – blood pressure low and pulse rate high. Something's not right."*

Anaesthetist: *"The chest drain that was put in ED has stopped swinging and there's fresh blood in it. The left lung has collapsed, I think."*

Surgeon 2: *"There's now bleeding coming from around the drain site on this side."*

Surgeon 1: *"We're going to open the chest. Scrub team and anaesthetics, are you prepped and set?"*

Scrub practitioner: *"Set and ready."*

Anaesthetist: *"Ready."*

Surgeon 1: *"Knife to skin…"*

Life as a surgeon is, in most respects, a routine existence and much of what we do is predictable. Operations are undertaken by a highly skilled multidisciplinary team of surgeons, anaesthetists, and theatre practitioners. A theatre represents a system within a nest of systems (an operating department, and a larger healthcare organisation) that collectively functions to produce several outputs, a successful operation being just one. On a typical day, this work is undertaken with high levels of predictability and minimal variation, and these systems usually work seamlessly, albeit under considerable pressure.

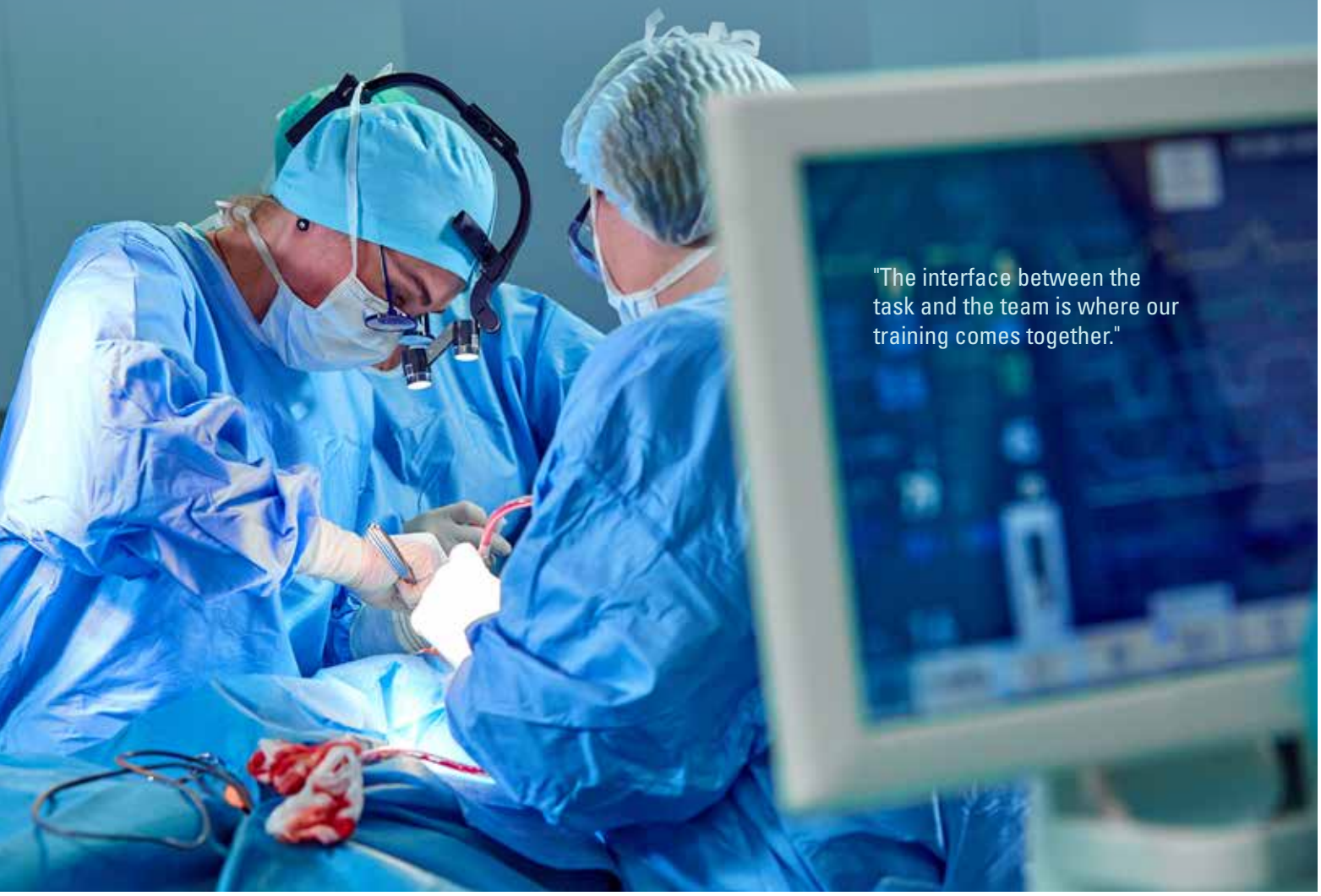
But, as illustrated in the hypothetical example above, life as a surgeon also involves managing the unpredictable in volatile, uncertain, complex and ambiguous (VUCA) conditions. We cannot predict when something unexpected will occur, but we know that we need to be ready for it and are trained with this in mind.

Training as a surgeon is a long-haul journey. For me, the journey from medical student to consultant vascular and trauma surgeon took almost 20 years. During the many years of surgical training, most of the focus is on operative experience; time and exposure in the operating theatre are critical. Unlike in aviation, we have yet to develop a simulator with enough fidelity to reproduce the conditions of theatre such that the next generation of surgeons could be trained well enough outside of a real-world environment to operate safely and handle unexpected events as a team.

There are three areas that need to be captured in training, all of which are covered through exposure to theatre over those two decades: a) development of the individual knowledge and skills to complete surgical tasks, b) development of the skills needed to work effectively within a multidisciplinary team, c) testing these skills under increasingly challenging conditions, including surprises.

The Austrian philosopher Victor Frankl said: *"Between stimulus and response, there is a space. In that space is our power to choose our response."* In a surgical theatre, when providing resuscitative trauma care, these stimuli are many, and can change unexpectedly and rapidly. The outcomes as a team will depend on how we detect and understand these changes and manage our responses.

While much of this comes down to those decades of individual training, all of it directly relates to the way that we work as a team. The interface between the task and the team is where our training comes together; our self-awareness and self-management as individuals help to ensure that we perform well together. So how do we create the right conditions for this?



"The interface between the task and the team is where our training comes together."

Over the decades of training that precede independent practice in surgery, there will be thousands of moments when the surgical trainee encounters operative scenarios where they will meet, for the first time while supervised, a new or unexpected event in theatre. In that moment, a space for learning is created and a new response is generated. These responses are embedded through repeated exposure and eventually become a matter of 'instinct'. Those patterns of response need to be supported and assessed at an early stage.

Novel circumstances can, however, come with a stress response. The years of exposure serve to blunt this stress response. This is partly because the surgeon increases their understanding of pathology (disease), operations, outcomes, and interactions between members of the theatre team. In doing so, the surgeon generates iteratively a unique personal repertoire of associated cognitive skills. The greater the exposure, the greater the opportunity to consider alternatives and options.

Also relevant to handling the unexpected is the fact that traumatic injuries might encompass any part of the body and present in a seemingly infinite array of combinations. The apparent complexity at any given point in time is high: the patient who needs our help has a unique injury burden and physiology, the composition of the group of people who will come together as a flash team to provide care across the patient's care pathway will be unique. These elements all need to be factored into the way that we undertake treatment, and all add to mental workload and thinking in the moment.

"In trauma surgery there are few surprises as such – with the typical emotion involved – just the predictably unpredictable."

To summarise, in trauma surgery there are few surprises as such – with the typical emotion involved – just the predictably unpredictable. Being able to respond effectively to rapidly changing information and situations as they develop requires training that focuses not only on the task, but also the team and our roles as individuals to integrate the two.

Mark Edwards is a Consultant Vascular and Major Trauma Surgeon based in the South East of England and Clinical Director for specialist services in Sussex. Mark oversees a service improvement portfolio that includes the implementation and study of methods of integrating serious incident data to identify patterns and trends across high acuity care pathways.

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FROM SURPRISE TO NORMALISE: HOW CAN WE BECOME CULTURALLY INTELLIGENT?

Surprises can reveal much about culture. In this article, **Nippin Anand** gives a maritime example that made him challenge his assumptions.

"Typically, our reaction to surprise is to make the strange familiar and close the gap between our expectations and experience."

It's 19:30 and four officers including the captain appear in the ship's messroom. The captain rings a hand bell to call the messman and asks him to serve them food. As the messman is leaving, the captain says, *"Edvin, turn off the music in the galley, don't you see we are eating."* The dinner timing onboard the ship lasts between 17:30-18:30 but Edvin later tells me that this has become an everyday affair. The music helps him unwind after a long day at sea, but he agreed that it could be a nuisance for someone who wants to enjoy their meal. As someone visiting the ship, I was left shocked and surprised by this experience.

When I look back more than a decade, this is a good example of a cultural indicator – that which is considered normal within a group (team, community, subgroup, another part of the organisation or another country) but surprises the outsider. A surprise is when our expectations are violated or something unexpected occurs and we struggle to make sense of it.

In all cultural dynamics, there are dominant groups and subservient groups. The dominant group – whose purpose is being served by the cultural indicator – will defend it as a matter of necessity (for example quoting a rule or a process) or utility (convenience). The subservient group that bears the consequences accepts it as a norm. I call it the *OK threshold* – the point up to which we have no desire to challenge status for the effort it would require. The captain defended the decision for eating outside the dinner timings because of the ship's hectic schedule. The mess man, on the other hand, does not see how raising a concern would change anything in his favour.

Making the Strange Familiar

As leaders, managers, investigators, and auditors, there are many instances when our expectations are proven wrong, and we are left surprised. Sometimes the language, behaviour, habits and heuristics of familiar people can surprise us, for instance when we meet people from another subculture (people from another village, suburb, regional offices, departments, management levels). How do we respond in those moments? Typically, our reaction to surprise is to make the strange familiar and close the gap between our expectations and experience. For example, we may have an ideal image about how a ship captain should interact with his crew and, upon witnessing a crew member being treated with disrespect, we may dismiss this as a one-off or simply downplay it as someone having a bad day. We are quick to make the strange familiar and in so doing, we lose the discriminatory details of our experience.

On the other hand, being too inquisitive about our surprises may not be an option either. If I questioned the captain for too long or challenged his perspective about a practice that has become accepted in this culture, chances are I will soon find myself outside of this group. I would be kept at a distance within the formal confines of a guest visitor. Culture is all about belonging and identity. If belonging to this culture is crucial for my survival (because I need to revisit the ship at a future stage or at least maintain a working relationship), I must find a way to align with the practices of this culture or come to terms with their 'normal'. That is the power of culture. To belong to a group, we often adapt our habits, language, gestures, and tone, and in most instances this happens unconsciously.

The Unconscious Mind

Another mistake we often make is seeing surprises as a symptom of behavioural problems (bad captain-submissive messman) and soon we want to conduct 'speak up' training and leadership courses.

We rarely question ourselves about the 'OK threshold'. Why have the norms that took us by surprise been accepted by the ship's crew? How long has this norm continued without being challenged? As we are wrestling within to make

sense of our surprises, it is convenient to create villains and heroes in our organisations. But such outcomes of social injustice are often the result of deeper cultural problems.

When I engaged with the crew onboard, I did not hear anything negative about the captain. To the contrary, I was told that this was a kind-hearted captain who would go out of his way to help his crew. It became clear that this was more than just a leadership problem. The fact that both the captain and the messman had normalised this experience in their world shows that normalisation is neither deliberate nor conscious. It is a byproduct of the history and legacy of the group. At some stage, someone may have started this practice out of a genuine need or a pragmatic solution to a persistent problem but over time this has become an automatic and implied expectation.

Once automaticity kicks in, anyone who joins the group will conform to the existing rules of that group. When a new crew member sees Edvin in the messroom outside of duty hours serving food to the officers – day in and day out – he or she will automatically accept this as the 'ground reality'. It takes a lot of courage to challenge a norm that is unconsciously accepted by the group. Do you notice a paradox here? It is the habits of the group that attract others to participate in the group. How can someone from within disapprove a norm or a practice that gives solidarity to the group? The acclaimed sociologist and a pioneer in cultural studies Pierre Bourdieu called it *habitus* (habit-us). It is a habit that we do without knowing why we do it.

On Becoming Culturally Intelligent

How do we manage the tension between 'surprise' and 'normalise'? And more importantly, how can we become culturally intelligent from our own surprises?

We might learn how to spot cultural indicators as an outsider in a group. For operational personnel, this may happen when swapping shifts or changing shift patterns, when becoming a manager, or when working in other organisational functions, such as safety management. Each has different cultural indicators.

When you are surprised about something while others are not, it is important that you hold on to your perspective. More specifically, do not rush to close the gap between your expectations and experiences. But at the same time, do not become too excited about it. There is a delicate balance between making the strange familiar and making the familiar strange. Managing this balance is the starting point to becoming culturally intelligent.

As in this example, your surprises may lead you into different directions. On the face of it, the captain may seem disrespectful, but no one really supported this view. That brings us to another important lesson in cultural intelligence – enjoy the ambiguities and welcome indecisiveness. All cultural indicators originate from the unconscious and surfacing the unconscious requires us to challenge our deeply held assumptions, entertain doubt, and revisit our worldviews. That is learning in true sense.

"There is a delicate balance between making the strange familiar and making the familiar strange. Managing this balance is the starting point to becoming culturally intelligent."

If you are fortunate to win the trust of the group (and the group leader), share your understanding about what you have learned about their culture. All learning begins from within. A good place to start when you share your observations with the group is how your surprises have challenged your own worldview.

Be mindful that you are surfacing norms and practices that have become embodied in the group's language, symbols, habits, heuristics, and it is part of the group's history. Being empathetic, humble, and open-minded about your observations is a crucial skill for winning trust and enabling change.

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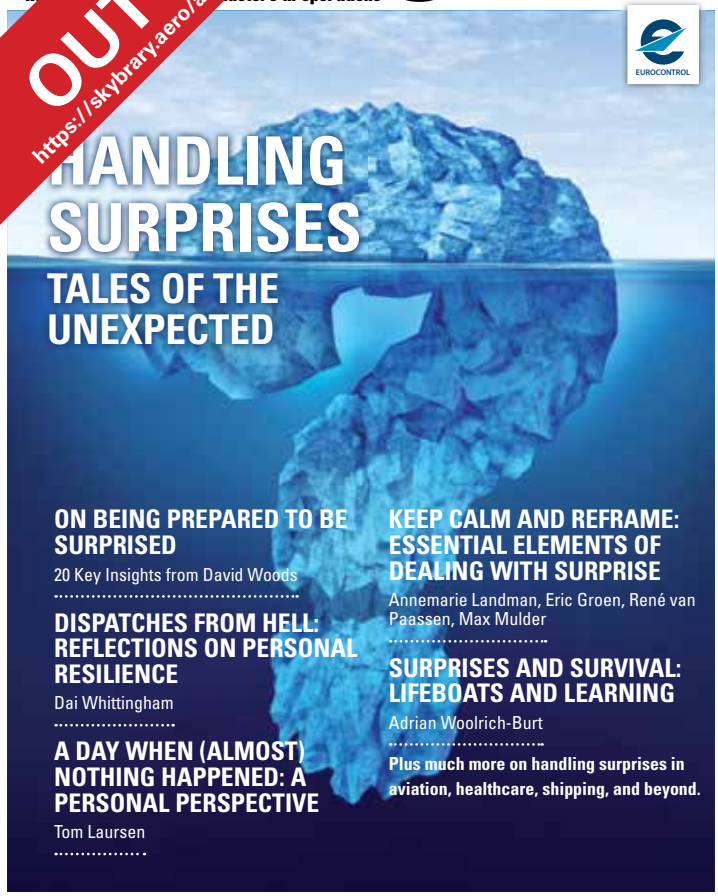

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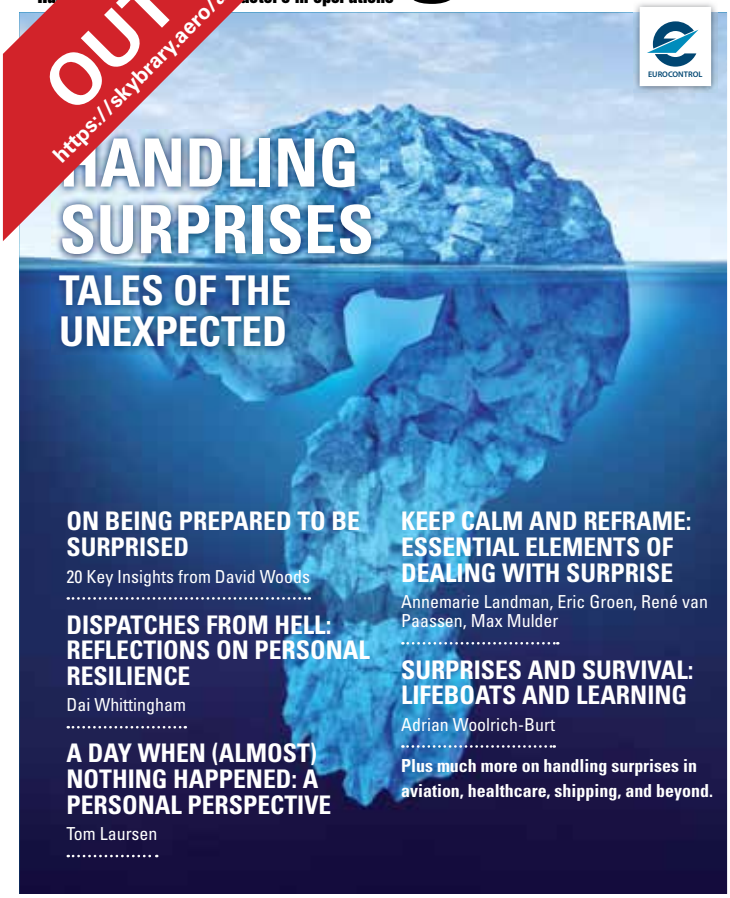

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WORK-AS-IMAGINED SOLUTIONEERING: TEN TRAPS ALONG THE YELLOW BRICK ROAD

On major projects, some surprises unfold slowly via 'work-as-imagined solutioneering'. Based on observations in several industries, **Steven Shorrock** presents ten traps that we can all fall into.

In the book *The Wonderful Wizard of Oz*, Dorothy is lost in a faraway land, and must travel the "road of yellow brick" to the Emerald City, where she will find Oz, the Great Wizard, who could help her get back to Kansas. Along the road, Dorothy is joined by three characters also in need of help from the Wizard: the Scarecrow who is in need of a brain, the Tin Woodman who is in need of a heart, and the Lion who is in need of courage. The three join Dorothy and her dog Toto on the yellow brick road, only to find their journey tormented by hazards and traps. Some of these are simply troublesome, like uneven, broken and missing bricks, and branches blocking the path. Others are deadly, including a very deep and wide ditch with *"many big, jagged rocks at the bottom"*, a *"pack of great wolves"*, a *"great flock of wild crows"*, a *"swarm of black bees"*, and *"monstrous beasts with bodies like bears and heads like tigers"*.

The road symbolises a path to a solution, but the road was not as imagined. And as it turned out, neither was the solution. At work, the chances are that you have come across a designed 'solution' that that did not solve the problem, perhaps even making your work more difficult. It could be a new computerised system, a new policy, or new performance target. Perhaps you've even found yourself on the yellow brick road yourself, blindsided by traps along the way.

In this article, I outline ten such traps on the yellow brick road to problematic solutions. The traps are presented in the typical sequence in which they arise in a process that I will call *work-as-imagined solutioneering*.

Trap 1. Complex problem situation

The process of work-as-imagined solutioneering starts with a complex problem situation. Complex problem situations occur in systems with:

- a variety of stakeholders with conflicting goals,
- complex interactions between stakeholders and other elements of the socio-technical system (visible and invisible, known and unknown, designed and evolved, static and dynamic),
- multiple constraints (social, cultural, procedural, technical, temporal, economic, regulatory, legal, etc), and
- multiple perspectives on the nature of the problem.

This is the first trap. In complex problem situations, problems tend to be interconnected to form what Russell Ackoff – one of the grandparents of modern systems thinking – called a 'mess': a system of problems. Solving one isn't enough.

"Complex problem situations are hard to understand and have no obvious solutions. This is unappealing to most people."

Trap 2. Complexity is reduced to something simple

Complex problem situations are hard to understand and have no obvious solutions. This is unappealing to most people. Understanding complex problem situations requires that we seek to understand:

- the various expressions of, and influences on, the problem,
- the stakeholders or people that influence the situation, and those affected,
- the work affected,
- the various contexts of work (e.g., physical, ambient, social, cultural, technological, economic, organisational, regulatory, legal), and
- the history of the problem situation and system as a whole.

At least one of these forms of understanding is typically lacking (usually more than one, and sometimes all five). This is partly because getting this understanding requires trust and expertise, which are often in short supply. And it is partly because, once a problem is identified, there is a perceived urgency to do something in order to reduce anxiety.

So the critical activities needed understand complexity are often neglected, and complexity is reduced to something simple, such as 'poor performance', 'non-compliance' or 'human error'. The second trap has been set.

Trap 3. Someone has a ready-made solution

While there may be little understanding of the complex problem situation, solutions are at hand. Past experience, ideas from other contexts, committee-based idea-generation, or diktats from authority figures make a number of appealing 'solutions' available. These form the third trap. Examples include:

- rules
- procedures
- checklists
- mandatory training
- commercial off-the-shelf products
- 'automation'
- quantified performance targets and limits
- measures
- reporting lines
- performance reviews
- incentives
- punishments, and
- reorganisation.

Most of these are not inherently bad. What is bad is introducing them – any of them – without a proper understanding of the context and the problem situation within that context. But the focus soon turns to the 'solution'.

Trap 4. Compromises to reach consensus

As the solution is revealed, people at the blunt end are now at the sharp end of a difficult process of design and implementation. There is a lack of expertise in how to do this, and disagreements emerge as people start to see a number of complications. But consensus and the stability of the implementing group is critical, and this is the foundation of the fourth trap. The idea is put out for comment, usually to a limited audience. There are further insights about the problem situation and context system, but these arrive in a haphazard way, instead of through a process of understanding involving design and systems thinking. Eventually, compromises are made to achieve consensus and the 'solution' is specified further. Then plans are made for its realisation. The potential to resolve the problem situation is hard to judge because neither the problem situation nor the context is properly understood.

Trap 5. The project becomes a thing unto itself

The focus now turns to realisation. The problem situation and context, which were always out of focus, are now out of view. The assets and real needs of all stakeholders were never in view, but the needs of the stakeholders who are invested in the roll-out of the solution have been met: they can now feel reassured that something is being done. The focus now switches from *what* to *how:* how can we implement this idea? Often this involves a heavy and inflexible plans, processes, structures, tools, management systems, and documentation requirements.

"At work, the chances are that you have come across a designed 'solution' that that did not solve the problem, perhaps even making your work more difficult."

Trap 6. Authorities require and regulate it

As the 'solution' gets more attention, authorities come to believe that it is a Good Thing. Sometimes, solutions will be mandated and monitored by those with regulatory power, but detached from the context of work. Now there is no going back (except to Trap 4 and 5).

Trap 7. The solution does not resolve the problem situation

The solution is deployed, but it is not even the same as the original idea. More compromises have been made along the way, in terms of the concept, design, or implementation (or all three). An unwanted surprise emerges at this point: the problem remains (albeit in a different form)! The feedback loops from the sharp end to the blunt end, however, contain delays and distortion.

Trap 8. Unintended consequences

Not only does the solution not resolve the original problem, but it also brings new problems that were never imagined! In general terms, this might mean more demand, more pressure, more friction, more complexity, or more use of resources. Such surprises often appear in the interfaces between different stakeholders, departments, organisations, etc. The parts of the system just don't fit. This may relate to the provision of monitoring, analysis, tools, materials, and technical support. Or it might just be that the deployed 'solution' cannot even function as intended, designed or implemented.

Trap 9. People adapt and game the system

At this point, operational work has to continue, somehow, *despite* the 'solution'. And so it is necessary to adapt and compensate. Many work-as-imagined solutions can be worked-around (e.g., 'gaming the system'). This is typical of measures (especially when combined with targets or limits) and processes, but we also work around clumsy technology, or indeed any of the 'solutions' listed under 'Trap 3'. Have a think about how you have worked around each of them.

Trap 10. It looks like it works

The adaptation and gaming, combined with feedback lags and poor measures, give the illusion that the deployed solution is working, at least to those not well connected to the context of work-as-done. By not illuminating work-as-done, which is successfully compensating for and hiding the flaws in work-as-imagined, the illusion of successful implementation is maintained. This trap is almost invisible.

Of course, there may well be a vague sense that there are 'teething issues', but this is easily rationalised away. Too often, we are left with gaps between the four 'varieties of human work': work-as-imagined, work-as-prescribed, work-as-done, and work-as-disclosed (Shorrock, 2016). There is a lack of alignment between how people think others work, how people are supposed to work, how people say they work, and how people actually work.

By this stage, the project team that worked on the originally intended solution has probably moved on. The deployed system remains and now we must imagine a solution for both the original problem and the new problems.

Back to the Yellow Brick Road

In the book, which is rather different to the film, the traps are of course quite different to those above. But some are analogous. Interestingly, it is the Great Wizard who adapts and games the system (Trap 9): Dorothy's three companions are fooled into receiving convincing counterfeits.

"Oz, left to himself, smiled to think of his success in giving the Scarecrow and the Tin Woodman and the Lion exactly what they thought they wanted. How can I help being a humbug," he said, "when all these people make me do things that everybody knows can't be done? It was easy to make the Scarecrow and the Lion and the Woodman happy, because they imagined I could do anything. But it will take more than imagination to carry Dorothy back to Kansas, and I'm sure I don't know how it can be done."

"Not only does the solution not resolve the original problem, but it also brings new problems that were never imagined!"

Indeed, the Wizard did not take Dorothy back to Kansas. How she got back was not how she imagined.

The story, and our experience, reminds us that top-down work-as-imagined solutioneering – like everything else – has limits. In the end, it tends not to solve the original problem and comes with unintended consequences, which are compensated for in ways that are hard to see.

So, next time you notice a 'problematic solution', either developing or deployed, perhaps it is worth trying to understand how it came to be. How did the 'solution' itself make sense during the process of its development? If work is now more difficult and less effective, the chances are that you will find a few of the traps above, which – by the way – we can all fall into. But more importantly, perhaps you can intervene to help realign work-as-imagined with work-as-done.

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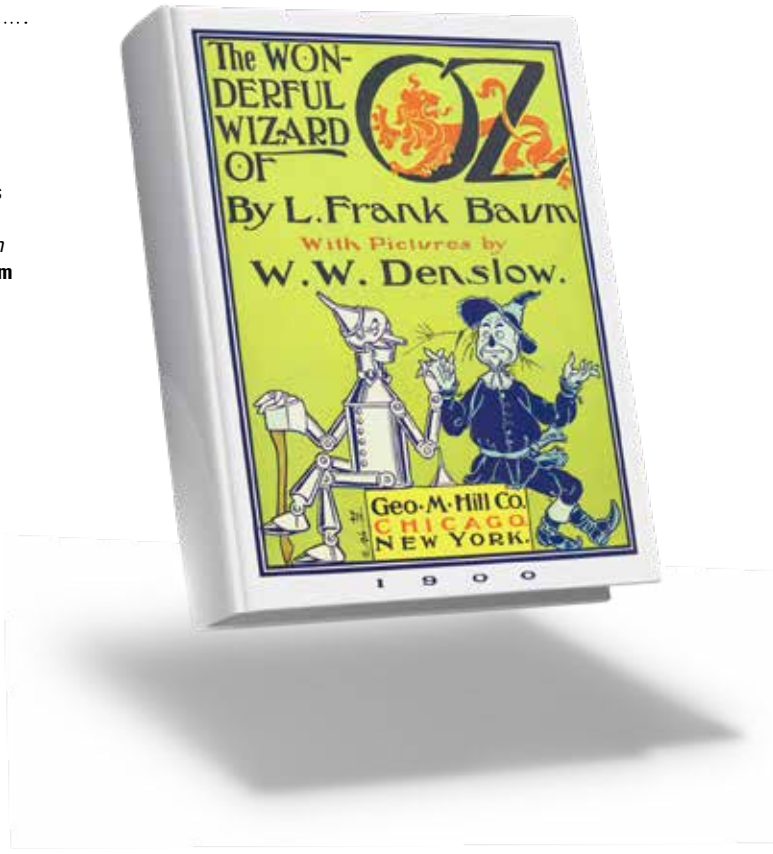


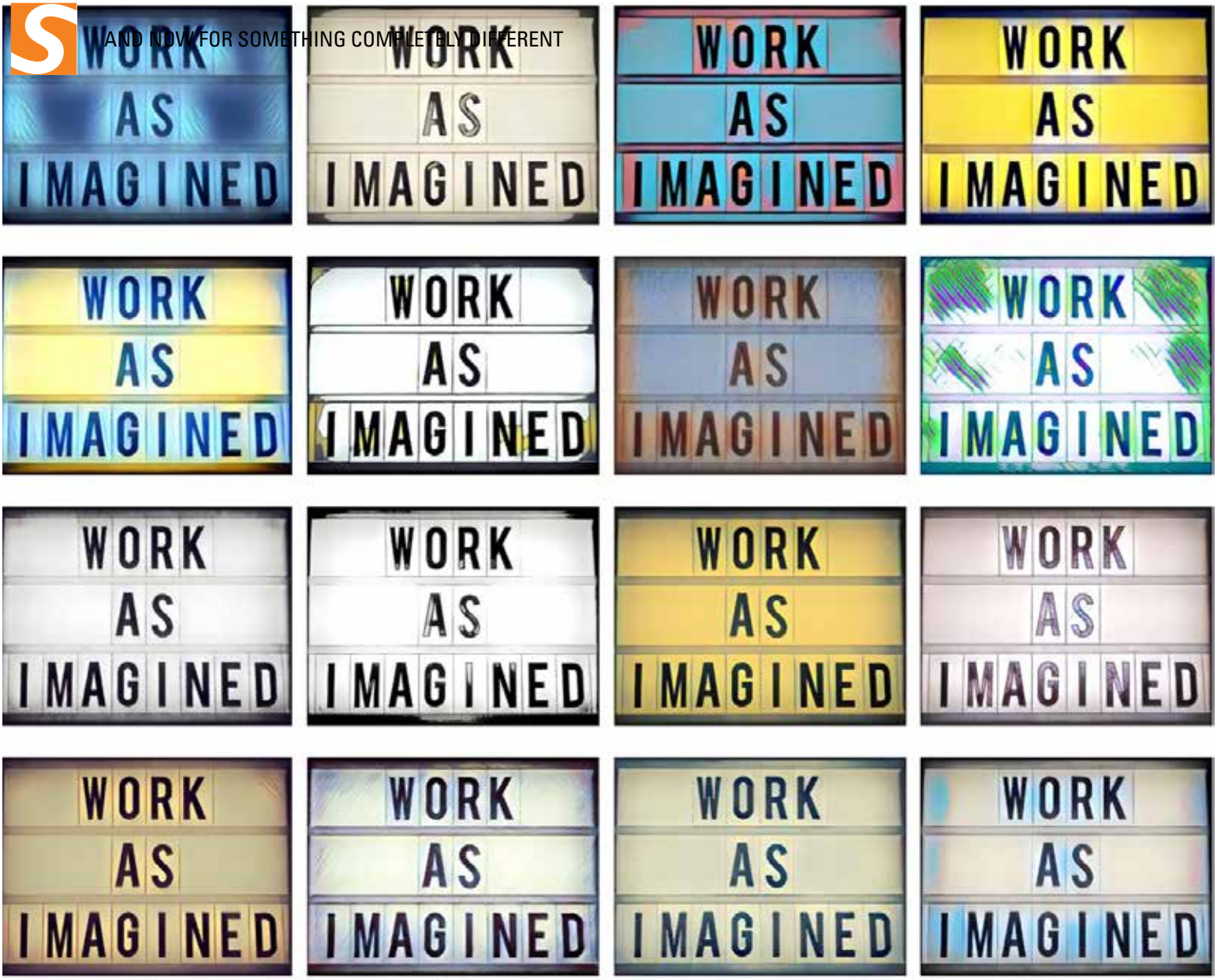


Photo: Steven Shorrock

"Over the last few years there has been a call to enshrine 'saying sorry' in law. This became the 'duty of candour'. When this was conceived it was imagined that people would find the guidance helpful and that it would make it easier for frontline staff to say sorry to patients when things have gone wrong. Patient advocates thought it would mean that patients would be more informed and more involved and that it would change the relationship from an adversarial to a partnership one. In practice this policy has created a highly bureaucratic process which has reinforced the blame culture that exists in the health service. Clinical staff are more fearful of what to say when something goes wrong and will often leave it to the official process or for someone from management to come and delivery the bad news in a clinical, dispassionate way. The simple art of talking to a patient, explaining what has happened and saying sorry has become a formalised, often written, complied duty. The relationships remain adversarial and patients do not feel any more informed or involved as before the duty came into play."

Suzette Woodward, Patient Safety Lecturer and Former Paediatric Intensive Care Nurse

"With the installation of a fully computerised system for ordering all sorts of tests (radiology requests, lab requests, etc.) work-as-imagined (and work-as prescribed) was that this would make work more efficient and safer, with less chance of results going missing or being delayed. Prior to the installation, there was much chat with widespread talk of how effective and efficient this would be. After installation, it became apparent that the system did not fulfil the design brief and while it could order tests it could not collate and distribute the results. So work-as-done then reverted to the system that was in place before where secretaries still had to print results on bits of paper and hand them to consultants to action."

Craig McIlhenny, Consultant Urological Surgeon

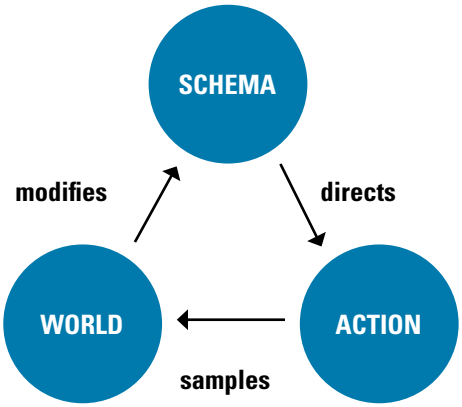
HUMAN PERFORMANCE IN THE SPOTLIGHT:

THE PERCEPTUAL CYCLE MODEL OF DECISION MAKING

In this series, human performance issues are addressed by leading researchers and practitioners in the field. **Katie Plant** gives some insights into the Perceptual Cycle Model as a framework to understand decision-making and automation surprise.

What is the Perceptual Cycle Model?

The Perceptual Cycle Model (PCM; Neisser, 1976) was originally conceived as a model to help understand how people process information. The PCM depicts a cyclical relationship between internal 'schema' (mental templates based on experiences and expectations) and information in the external environment. These schemas are triggered by situations and 1) lead to the anticipation of certain types of information, 2) direct our behaviour to sample or seek out specific information, and 3) provide a way to interpret that information. Our perception and experience of the environment can result in the modification and updating of our schemas, which in turn influences further interaction with the environment.



Why is it a useful framework to understand decision-making?

We cannot begin to understand work and safety without understanding the underlying processes that sit behind decision-making. In relation to failure situations, the term 'local rationality' accounts for why decisions and assessments made sense to the operator at the time they were made, given the context. The PCM can account for this process and facilitate our understanding of *why* a decision was made (rather than just looking at *what* decision was made) by embedding our understanding of decision-making in the wider context of the operating environment. The PCM is a useful framework for understanding why it made sense for an operator to do what they did, in light of the schema (past experiences and expectations that are used to rapidly categorise situations) and information in the wider environment (i.e., standard operating procedures, communications, technology, organisational culture) available to them at the time decisions were made. Importantly, the PCM emphasises the processes involved in decision-making, rather than the output. If a way of behaving made sense to one person, is it likely to make sense to another. Once we understand that, we are able to support operator decision-making. This might be through system design or decision aiding and training activities.

"We cannot begin to understand work and safety without understanding the underlying processes that sit behind decision-making."

Will different people have different perceptual cycles for the same situation?

In a nutshell, yes. It is argued that no two people will ever have precisely identical perceptual cycles because they will have different past experiences (schema) which are a key driver for decision-making. Even in an environment like air traffic management, where controllers are selected based on similar aptitudes and undertake the same training programmes, the precise nature of the schema that they hold will vary. This may be because they have internalised training in different ways or been exposed to something in an operational context which influences the expectations they now hold about a situation. Of course, work in safety-critical systems should be in accordance with standard operating procedures and regulations, but when things start to go wrong, people may revert to more automatic behaviours underpinned by their perceptual cycle.

How is the perceptual cycle framework relevant to automation surprises?

'Automation surprise' is an action performed by the automated system that was unexpected by the operator. On the flight deck, this is

often described as the pilot not fully understanding some aspects of the aircraft's automatic flight control system. If we think about this from the perspective of the PCM, then we need to understand the schemas that are held, the available information in the environment and the actions or decisions undertaken by an operator. The way in which an operator engages with an automated system will be influenced by the schemas that they hold for that system, i.e., what they expect to happen based on past experiences (which may include training, operational experience, or even vicarious experience from other people). This is coupled with information available to them in the world (e.g., what the system is telling them about status or mode). The occurrence of 'automation surprise' suggests a mismatch between the operator's schemas and the information in the world. Modelling an automation surprise event with the perceptual cycle framework would enable an understanding of what schemas were held by an operator, what information was available to them and how these interacted to result in automation surprise. Traditionally, operators have been blamed for not maintaining an accurate mental model or picture of automated systems, though arguably automated systems that cause surprise have not been designed or trained for in order to support the ways in which operators perceive information and make decisions.

How can people be supported to make 'better' decisions?

A central tenet of the PCM concerns the role of schemas in decision-making. Schemas are built through past experiences and are advantageous at reducing cognitive expenditure by directing attention and influencing action. They can, however, leave operators vulnerable to suboptimal decision-making if their schemas are inappropriate for an operational context. The perceptual cycle model can be used to enhance decision aiding and training. For example, operators can be trained in perceptual cycle processes to understand how internal schema and external information interact and influence decisions and actions. Operators can be trained on sources of potential bias from the schemas that they hold, which may result in suboptimal decisions. Critical incident training can encourage operators to reflect on assumptions they may bring into a situational assessment and critically evaluate the information they have available to them. This can help to avoid 'cognitive lockup' or tunnel vision. Similarly, interfaces and systems can be designed to support natural decision-making processes, by using the PCM for presenting information and designing interfaces that adapt to different situations.

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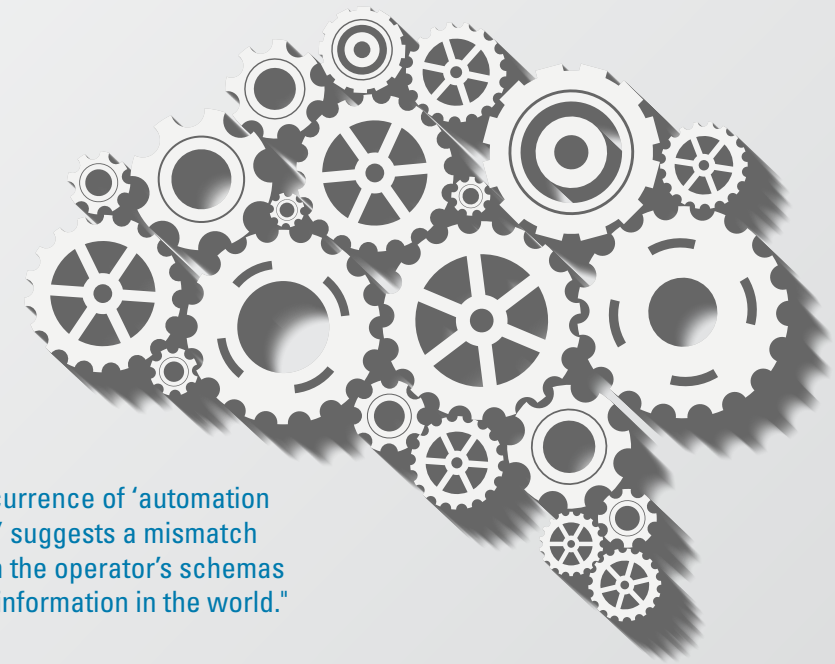


"The occurrence of 'automation surprise' suggests a mismatch between the operator's schemas and the information in the world."

REPOSITIONING INCLUSION AND DIVERSITY IN ATM

I started my ATM journey in 1995 at BULATSA, Sofia ACC. At the time we still had only one radar, which was one more than our colleagues in Athens. Now I work in Maastricht ACC where we use 49 radars. During my career I witnessed a massive change in the technology we use (see also Technology 2.0 by Tony Licu in *HindSight* 33), tremendous traffic demand and developments in safety such as human factors, fatigue management, work as done vs work as imagined, automation, and resilience.

In parallel, another demographic shift also happened: ATM welcomed more women as controllers, engineers and managers. The professional careers stretched, and so now more generations work together. We also witnessed changes in society such as advancement of gay rights and the rights of people of colour. Migration waves within and to Europe made the big cities melting pots of different religions and ethnicities. We now take for granted that we must accommodate in the workplace people with visible and invisible disabilities. These societal changes transformed the fabric of the ATM workforce, calling for a deliberate effort for more inclusion in the workplace. Yet, ATM still has to reflect on how these changes influenced its workforce and organisational cultures. I hope this *HindSight* column will help to fill this gap by presenting good practices, different viewpoints and human stories.

But why focus on equity, diversity and inclusion (EDI)? First, we need talented people. Many ANSPs try to attract, select and retain young people to specialise in our niche industry as ATCOs, ATSEPs, experts or managers. Compared to 20 years ago, many ANSPs have to work harder on recruitment so that we can staff our ranks. Collectively, we could exchange good practices and realise economies of scale. We could improve our industry and the perception of it, so that we can compete effectively on the labour market.

"A diverse workforce will bring along people with different backgrounds with more knowledge and different approaches to understanding and resolving problems."

Second, diversity can help with the digitalisation that has already changed profoundly the ways we track aircraft, exchange data on ground and air, communicate, and work from home. We know that we – the whole network of airline operators, airports, ANSPs, and the Network Manager – need to innovate and implement different technologies to cope with the demand for more ecologically sustainable air transport. A diverse workforce will bring along people with different backgrounds with more knowledge and different approaches to understanding and resolving problems. Some companies recruit diverse teams already as a core of their HR and innovation strategies. However, without inclusion, people will not feel safe to voice unorthodox ideas. Non-inclusive companies will lose the benefits of diversity. We need to understand how we can increase the feeling of inclusion to make best use of the existing diversity.

Third, the question we need to ask ourselves is not if we want more diversity but how we deal with the increased diversity. Cities such as Paris, London, Amsterdam, and Brussels are already (or about to become) 'super-diverse'. This means that the biggest ethnicity of their population is less than 50%. In addition, we see a generational workforce overhaul where younger people are influenced more by values and culture than financial reward when choosing a workplace.

Finally, there is our contribution to the society we serve beyond our immediate mission to provide safe air traffic management. Organisations and communities cannot flourish and progress in a society torn of inequalities. We not only live in diverse societies but also in a hyper-connected world that is changing the how we live and work.

For these reasons, we need to engage and exchange with one another about the myriad aspects concerning the EDI topic.

I also want to acknowledge the strong backlash caused by clumsy equality, diversity and inclusion efforts. I get it. The most frequently received lines, when people dare speak openly about it, are "I've had enough of the women issue!" or "It really does not concern me at all." A lot of people feel they have been accused implicitly with a discriminatory attitude toward gender, race or religion. A thoughtful effort on inclusion will avoid this polarisation.

Dennie Coumans did not think too much about inclusion either. Dennie is a 1.93 m (6'4") tall active Dutchman and a customer service engineer. For many years he had worked in Lagos, Nigeria to support the maintenance of Dash8-400 and CRJ900/1000 aircraft and enjoyed a very successful career. That was until one day, back in 2017 when he suffered pneumonia. He had to be admitted to the hospital and within three hours lost mobility up to his chest. Life changed abruptly and profoundly. Suddenly, Dennie and his family had to adjust to a very different life. He also had to retrain and transfer his knowledge to Safety and Quality to continue working. When Dennie and I had a chat, I asked him: *"Do you think your company would have hired you in the first place at Safety and Quality if they did not know you before?"* It's worth thinking about.

If you want to see and hear Dennie, you can watch the first episode of the Inclusion and Diversity series in the EUROCONTROL Learning Zone (https://learningzone.eurocontrol.int). And you can read an interview with Dennie by *HindSight* editor Steven Shorrock in this issue.

In this and the next articles, I will try to shed a light on how we can bring up the topic in a constructive and inclusive way and highlight some of the best practices in the field.

Milena Bowman at EUROCONTROL
milena.bowman@eurocontrol.int

THE DAY THAT CHANGED EVERYTHING: FROM PARALYSIS TO GROWTH

Some people can identify a day where everything changed in a way that was previously unimaginable. For **Dennie Coumans**, this day came at the end of December 2017. What happened totally reshaped his life, as **Steven Shorrock** reports.

Dennie Coumans lives in the Maastricht, the Netherlands, with his wife and daughter. Five years ago, as an engineer for a base and line aircraft maintenance company, he was supporting African operators in Europe and Africa with maintenance along with his team. With travel to Rwanda, Nigeria and Cape Vert, life was intense.

At the end of 2017, life changed forever. Dennie felt unwell, and went to hospital with his father, where he was diagnosed with pneumonia. Despite intravenous medication, he was becoming sicker by the day. On the fourth day, he experienced one symptom that was not characteristic of pneumonia: *"While I was walking, I couldn't feel my big toes. I could barely walk."* Feeling unstable, he went back to bed.

Three Terrible Hours

Over the course of three hours, the motion and sensation disappeared from Dennie's body. *"It started in the feet, went up, and stopped at my chest. I was paralysed. It was very, very frightening."* He didn't know when or where it would stop. Now, those three intense hours are blurry. In a state of trauma, his mind did not record it. His wife told him that he was in a state of total panic.

Dennie was taken into the MRI scanner. He had suffered an infection that was putting pressure on his nervous system. It was his fortieth birthday. *"Instead of having a party, I was lying in bed, paralysed."*

In the weeks that followed, doctors tried to treat the infection from his spine. But it had been there too long. The damage was permanent. The infection turned out to be from a common bacteria, but Dennie's body had a severe reaction. He remained in hospital for five weeks.

"It started in the feet, went up, and stopped at my chest. I was paralysed. It was very, very frightening."

From Hospital to Rehabilitation

Once out of hospital, Dennie was taken to a rehabilitation clinic, where a team started to help him on his journey back to independence. *"It was a huge rollercoaster for me and my family, especially my daughter. Before, I was doing a lot of mountain biking, hiking, and travelling. But an instant, everything changed. It's difficult to describe it. In one day, you lose your life."*

Dennie had to start rehabilitation from "rock bottom", and the training programme was challenging. He was taught how to swim again. At first, he could only float, with help of therapists and buoyancy aids. It took months to learn to swim again.

And, of course, he also learned how to take care of himself in everyday life. *"But I had to let go of the things I could not do any more, which was very difficult. Still, some things are difficult to let go of."* He had many setbacks. But over time, he managed to start looking at things in a different way. *"My life was taken away from me, but I took it back."* He started

to see the things that he could still do. He met others with even more severe disability. *"I was happy I could still use my arms."*

Physical disability often comes with mental health problems, but it is impossible to imagine the impact of such sudden disability. Dennie had the help of therapists, and undertook training to help his recovery. He would do cooking lessons, hand biking, and wheelchair rugby. Joining the hand bike team was a revelation. He enjoyed being outside on the hand bike and part of that community. *"Sometimes I was very angry with setbacks. But I never had the thought, 'this is it. I cannot deal with this any more.'"*

Ultimately, the training became too much. Overtraining the body became a sort of escape: *"I was trying to keep busy, to try not to think a lot"*. What helped was social connection. There was another man of a similar age, in a wheelchair for around five or six years, and Dennie would ask him for advice. *"I had a lot of good conversations with him. He helped me a lot. He did not give me any answers, but he gave me tools to find the answers."* Dennie came to realise that everybody in the clinic had their own disability and their own challenges. What was an answer for him would not be an answer for somebody else. *"You have to find your own way"*, he said.

Coming Home

He left the clinic and went back home. Dennie explained that, *"Then the real training started. In the clinic, you have therapists around you. You have an alarm. They can help you 24/7. It's a safe environment. Now, you go home and you don't have the alarm any more. The house is not adapted. The world around you is not adapted."*

I wondered about the feelings that impacted Dennie the most. He said that some of his friends asked him why he was not angry about his situation. Wasn't there something inside him, waiting to explode beneath the calm exterior? *"I was quite calm about this situation. Of course, I felt it was very unfair. Why me? But there was nothing I could have done to avoid it."* He was told that the bacterial infection was inevitable.

Dennie began to understand that he was grieving: *"During the process of my rehabilitation, I had certain feelings and thoughts, and there were situations. And then somebody told me, 'Well, this is normal, as you are now in a process of grief. How I felt, how I reacted, was because I was grieving for not being the original Dennie, but Dennie, 2.0."* Sometimes, he still grieves. There is grief for the 'counterfactuals': what could have been, what he expected, what he envisaged. An example is seeing families travel without any disability. Dennie's family have to plan things that others don't even need to think about. But he never lost hope. *"I was always trying to see the positive things."*

Dealing with the Environment

I wondered what Dennie notices now that he didn't notice before about the built environment.

"There are a lot of challenges. The world is not built for people in a wheelchair. A lot of shops have stairs. In restaurants, most toilets are upstairs or in the basement. And if they are on the same level, they're too small." Before 2019, he didn't notice people in wheelchairs or their challenges. Now, he experiences those challenges everywhere. *"I also realise you cannot build the world for wheelchair users. So I have to deal with it in a flexible way. Certain situations can make me angry. But in most cases, I just try to find a way around."*

He tries to see his wheelchair not as a symptom of disability, but as a tool, which gives him mobility. His reframing helps him to see life differently: *"Those wheels give me full freedom to go outside."*

In the home, Dennie and his family had to build or adapt everything: kitchen, bathrooms, bedroom. It took four and a half months.

At work his old engineering job was primarily office-based, but sometimes required travel to check problems with an aircraft or visits to base maintenance. *"When the aircraft are in base maintenance, I cannot enter them now. So that was also quite a setback for me"*, he explained. His office in the engineering department was also on the second level, with no elevator. So his employer gave him a different job in the quality department, on the ground floor, and installed automatic doors. *"They made a lot of effort to get me back in the company and give me the things I needed. I now create human factors training at the quality department. I'm very happy. I'm very grateful."* He still keeps in touch with work-as-done, occasionally watching the engineers working on the aircraft.

Changes to Identity

Disability comes with changes to identity and relationships. I wondered how it was for Dennie, adjusting to a new identity, professionally and personally. Dennie is 193 cm (6'4") and described how *"I was quite a presence when I would enter a room. But now I'm in the wheelchair. So I try to work on my appearance. I do a lot of power gym and biking. I try not to eat too much because to lose weight in a wheelchair is difficult."*

It is not just about physical appearance, but 'presence'. *"When I look to people, it's like, 'I'm Dennie. I'm here. And it's okay for me to be here still participating in life and work.' I try to present that to people.'"*

Some people aren't sure how to react. But for Dennie's friends and family, almost nothing changed. Most of his friends are still around, and the wheelchair isn't an issue any more. He has good contact with friends, and some relationships became even better. *"They say, 'We don't see the wheelchair. We can only see Dennie.'"*

Growth

After recovery from a traumatic event, many people experience post-traumatic growth, where a person rebuilds their life in a way that adds richness and meaning. People can also become stronger or more resilient to other challenges and develop new capacities and capabilities, whether physical, mental, social, or otherwise. I wondered about how this might have applied to Dennie.

In 2018, during early recovery, a nurse told Dennie that he'd always need help to take care of himself. This was a trigger

for him. *"I never forgot that conversation", he said, "And I thought to myself, 'We'll see about that.' I'll go through everything to take care of myself."*

Dennie regained his independence. *"I even cook now three, four times a week. I never did that before."* And he drives a minibus to get around. *"I feel the freedom even when I'm in the traffic jam."* A 20 km hand bike ride is just a *"short ride"*, and from being unable to swim in the first days in the pool at the rehabilitation centre, now he can swim for one or two hours without floating devices – *"pure arm power"*.

In June 2022, he went with a hand bike team to Austria to climb a mountain: 20 kilometres and 900-metres elevation. It involved a lot of training. *"That is one of the things that I wouldn't have done before. But it takes a lot more effort for me to do it, a lot of preparation."*

He also gained a new appreciation for 'the mundane' – the ordinary delights and freedoms that most people take for granted or don't even see. *"Before I was always rushing, a lot of working. Now I can really enjoy the small things in life. When I'm outside with our dog, I can stop for five minutes and just listen to the birds. Yesterday evening, I was doing handbiking and saw a sunset. I can really enjoy such moments. Or when I spend more time with my family, playing games with my daughter. It's those little details in life. I can live in the moment now, not always thinking about tomorrow or next week."*

These are the freedoms that most people don't even think about. *"People don't realise the freedom they have, even to get out of bed, when you have no disability."* Before, he too didn't notice people in a wheelchair. But he developed a new level of empathy for people with disabilities and illnesses. *"When I see people now, I really realise the suffering, and the challenges."*

His biggest strengths, according to Dennie, are a new level of personal resilience, a completely new perspective on life, and an ability to live in the present moment…and appreciate it.

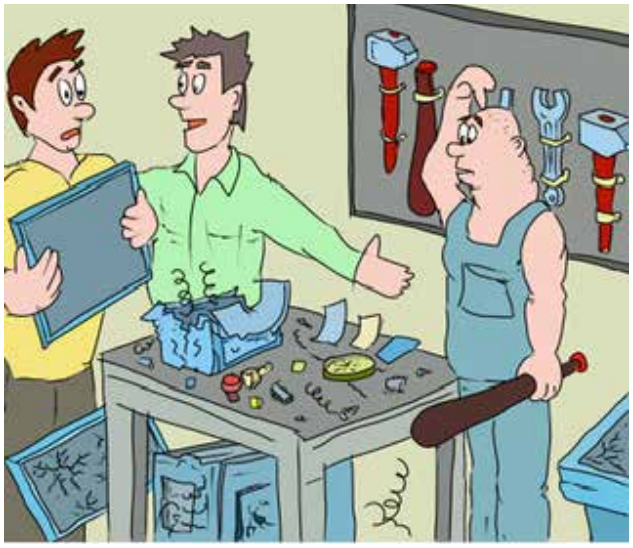
Despite – or because of – his life-changing event and the long process of rehabilitation, Dennie enjoys the small things in life: *"I try to make the best of it with friends and family. I go out biking by myself, and that's a great feeling. My employer gave me the opportunity to stay. I have setbacks and days that are heavy. But in general, life is good. I really like to be alive. And I'm very happy."*

After my Human Factors research in 2003 at the Garuda Indonesia maintenance facility in Jakarta, I graduated from the Amsterdam University (Bachelor Aeronautical Engineering). Via Air Exel Operations and Martinair Technics, I started as a Customer Service Engineer in 2007 at Samco Aircraft Maintenance. From 2007 until my life-changing event in 2017, I supported various African operators with the day-to-day operation and heavy maintenance preparation. I currently work at the Quality Department.

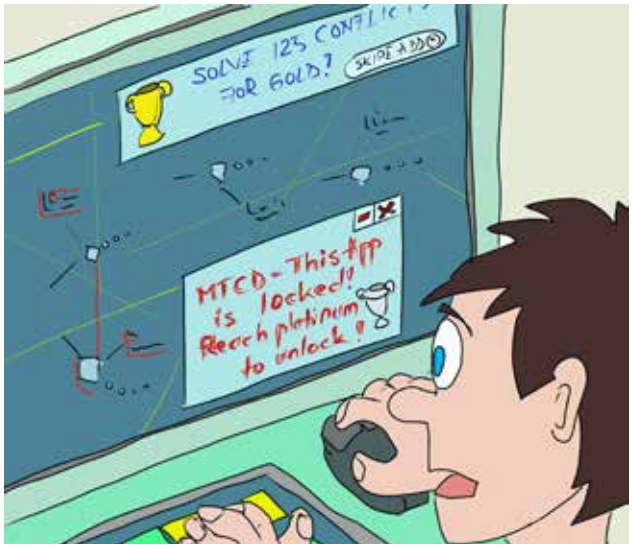
I live in Maastricht, Netherlands, with my beautiful wife, wonderful daughter and our little dog. I love to ride my handbikes on outdoor trails. During my rides I enjoy the beautiful nature, silence and epic sceneries. Photography and handbiking is my golden combination. I also love to read, to build with Lego, and music energises my soul. Since my life on wheels, I also love to cook. But aviation has been my passion since I was young, when my father took me to Maastricht Airport. The DC10, L1011 Tristar and Boeing 707 are my favourite aircraft.

"We now have a solution for the blackout,
But we need to adjust sector capacity due to the controllers' physical condition…"

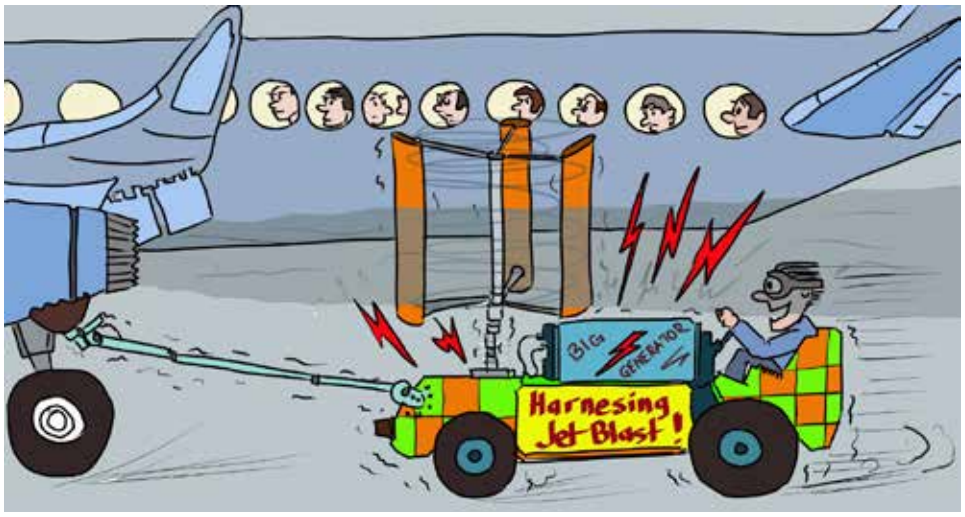
"Security, please find out who left the window open again!"



"Let me introduce the new complexity reduction expert!"



The outsourced software included some surprising features.



Our new concept: Follow You Car!
We generate green energy from otherwise wasted jet blast!

"Sorry BigJet 123! VASIS is out due to energy restrictions. But fortunately we have our neighbours decorations to help you land…"

The new pandemic masks came in useful in the end…

"Should we tell them it's just a high-fidelity simulation?"

The new tsunami alarm was a surprise to everyone in the Alps…

ENAIRE AND EUROCONTROL HOST CRITICAL INCIDENT STRESS MANAGEMENT CONFERENCE

The European critical incident stress management (CISM) conference was organised by the E-CISM network, ENAIRE and EUROCONTROL. It took place on the 13th and 14th of October 2022 in Madrid.

The hybrid-format conference was attended by representatives from EUROCONTROL, the International Civil Aviation Organization, and experts from Australia, Austria, the United States, Qatar, Ireland, Greece, Poland, the United Kingdom, Sweden and Spain.

Ángel Luis Arias, ENAIRE's CEO, opened the first day by noting that "air traffic management is a highly complex technical system that operates in a changing environment. Keeping the system safe, efficient and effective requires adaptation and flexibility. The people who control aircraft, and those who design and maintain the equipment, are the ones who create safety".

He added that "ENAIRE has worked very hard to consolidate its CISM programme, establishing very clear standards defined by EUROCONTROL and the Foundation for Stress from Critical Incidents, which include updated manuals and protocols, and very rigorous training for all our peers. We have a fantastic team of peers, all of whom are very committed to helping their colleagues whenever necessary." He thanked those involved for their volunteer work.

In general, members of specific professional groups, such as emergency services, pilots and air traffic controllers, are better prepared to handle unusual situations due to their experience and training. However, there are events that go beyond professional experience that can be potentially traumatic, and which are defined as critical incidents.

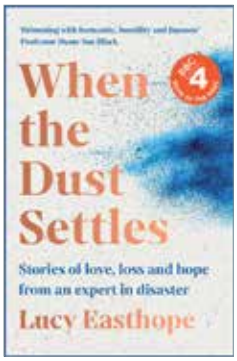
A critical incident is any situation, whether professional or personal, that happens suddenly or unexpectedly and that has the potential to create highly stressful reactions that can manifest themselves in a wide variety of ways, and that affects professionals over the course of their work in the control room. In short, they are normal reactions to unusual events.

The talks ranged from the organisational to the personal, from stress to PTSD, and were delivered by air traffic controllers, pilots, psychologists, psychotherapists, HR specialists and safety specialists, from sectors including aviation, fire and rescue, and healthcare.

Recordings and slides are available at https://bit.ly/3WweJUd

See the programme and speaker profiles in the message by Guadalupe Cortés Obrero, co-chair of the EUROCONTROL Safety Human Performance Subgroup and responsible for ENAIRE's CISM programme, at https://bit.ly/3jaHmaX

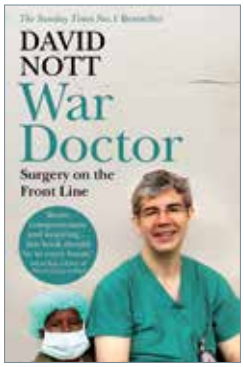
If you want to read more about some of the issues raised in this issue of *HindSight*, then these books might be of interest.



When the Dust Settles, by Lucy Easthope (2022)

From the publisher: "When a plane crashes, a bomb explodes, a city floods or a pandemic begins, Lucy Easthope's phone starts to ring. Lucy is a world-leading authority on recovering from disaster. She holds governments to account, supports survivors and helps communities to rebuild. She has been at the centre of the most seismic events of the last few decades, advising on everything from the 2004 tsunami and the 7/7 bombings to the Grenfell fire and the war in Ukraine. Lucy's job is to pick up the pieces and get us ready for what comes next. Lucy takes us behind the police tape to scenes of chaos, and into government briefing rooms where confusion can reign. She also looks back at the many losses and loves of her life and career, and tells us how we can all build back after disaster. When the Dust Settles lifts us up, showing that humanity, hope and humour can – and must – be found on the darkest days."

"Her sensitive and profoundly moral book explores how human beings can preserve their resilience and live with loss." (New Statesman)



War Doctor: Surgery on the Front Line, by David Nott (2020)

From the publisher: "For more than 25 years, surgeon David Nott has volunteered in some of the world's most dangerous conflict zones. From Sarajevo under siege in 1993 to clandestine hospitals in rebel-held eastern Aleppo, he has carried out lifesaving operations in the most challenging conditions, and with none of the resources of a major metropolitan hospital. He is now widely acknowledged as the most experienced trauma surgeon in the world.

War Doctor is his extraordinary story, encompassing his surgeries in nearly every major conflict zone since the end of the Cold War, as well as his struggles to return to a "normal" life and routine after each trip. Culminating in his recent trips to war-torn Syria—and the untold story of his efforts to help secure a humanitarian corridor out of besieged Aleppo to evacuate some 50,000 people—War Doctor is a heart-stopping and moving blend of medical memoir, personal journey, and nonfiction thriller that provides unforgettable, at times raw, insight into the human toll of war."

"His stories of courage and compassion in the face of seemingly certain death are breathtaking." (Fiona Sturges, The Guardian)

HANDLING SURPRISES EUROCONTROL ALC COURSES

The EUROCONTROL Aviation Learning Centre, located in Luxembourg, develops and delivers air traffic management training, services and tools for air navigation service providers, airlines, training organisations and civil and military State authorities worldwide.

Building on over 50 years of expertise, the centre provides a wide range of training courses, services and tools - from general introduction courses on ATM concepts through to advanced operational training. Here are some courses that may be of interest to readers on the topic of **handling surprises.**

Unusual and Emergency Situations [ATC-UNINC]

Emergencies are complex in nature. When one emergency occurs it may trigger other emergencies. The current emergency may in turn have been triggered by another.

This course helps ATCOs to understand the characteristics or circumstances of 15 selected unusual or emergency situations. It provides background information about how these situations may arise and their effect on aircraft and crew. The focus is on urgent and essential actions which ATCOs should take to manage the situation and assist the aircrew.

Objectives
Understanding of the nature of occurrences (whether an unusual situation or an emergency) by providing background information about how a variety of occurrence arise and their effect on aircraft and crew.

Building on the 15 proposed checklists for emergencies and unusual incidents which form part of the EUROCONTROL work to enhance "controller training in the handling of unusual incidents".

Audience
- ATCOs
- ATC AB-initio students

Introduction to TCAS [ATC-I-TCAS]

This refresher course is aimed at air traffic controllers who wish to enhance their knowledge of TCAS operations. The course focusses on items that matter to air traffic controllers and includes not only a review of how the system works but also includes sections on interaction with ATC during RAs, nuisance RAs, visual separation and aircraft in close proximity.

The course includes a number of interviews with pilots who share their experiences of TCAS operations, simulations of real operational examples and simulations of pilot responses to TCAS events.

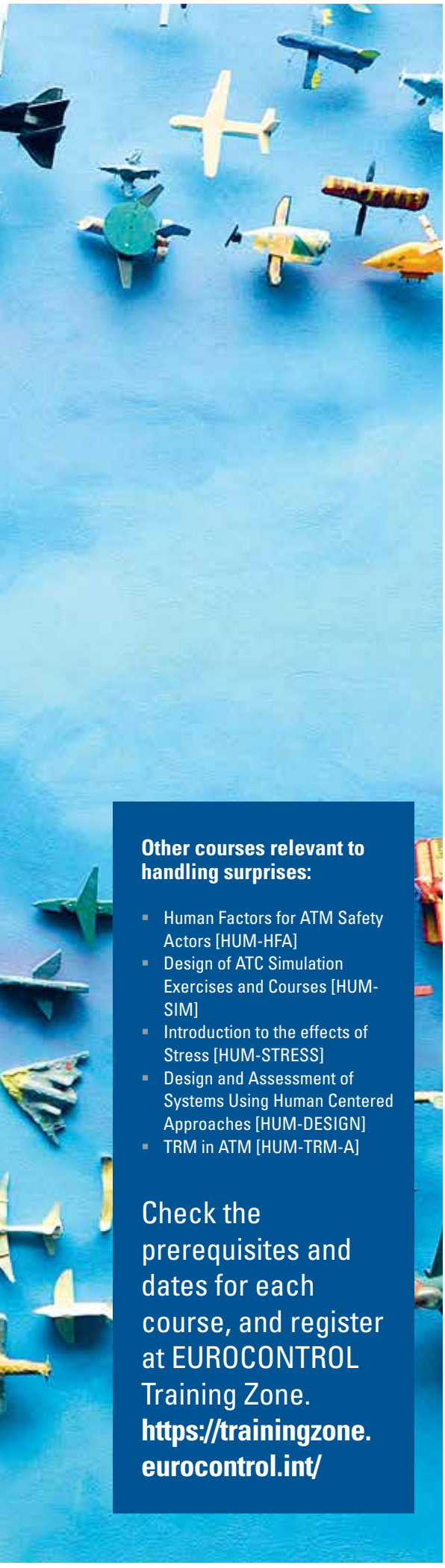
The subjects covered in this course include:

- Introduction and history
- TCAS Equipment and alerts
- Collision avoidance logic
- TCAS Operations
- ATC and TCAS
- Pilots and TCAS
- Technical and operational issues

Objectives
By the end of this course, participants should be able to:

- Explain how TCAS works
- List the types of ACAS
- Describe the types of TCAS alerts
- Describe the pilot respond to TCAS alerts
- Explain the logic and limitations of TCAS
- Describe the types of interaction that may occur between ATC and TCAS
- Explain the responsibilities of pilots and controllers in the event of an RA
- Describe TCAS technical and operational issues that may affect ATC

Audience
Operational air traffic controllers, and anyone who would like to have a better understanding of TCAS operations.

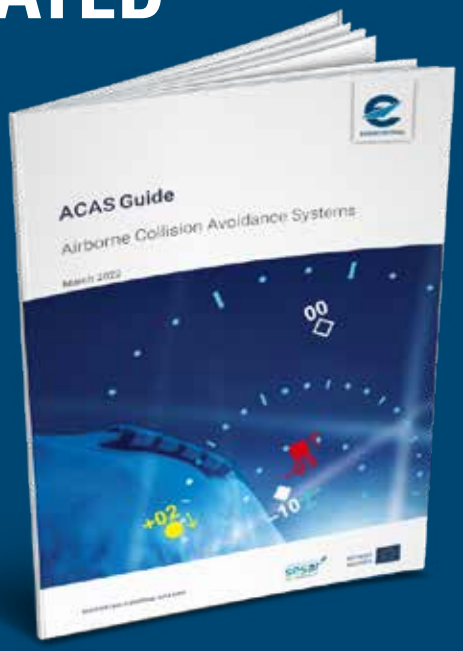


Other courses relevant to handling surprises:

- Human Factors for ATM Safety Actors [HUM-HFA]
- Design of ATC Simulation Exercises and Courses [HUM-SIM]
- Introduction to the effects of Stress [HUM-STRESS]
- Design and Assessment of Systems Using Human Centered Approaches [HUM-DESIGN]
- TRM in ATM [HUM-TRM-A]

Check the prerequisites and dates for each course, and register at EUROCONTROL Training Zone. **https://trainingzone.eurocontrol.int/**

EUROCONTROL ACAS GUIDE UPDATED



Six new EUROCONTROL ACAS Bulletins were published in 2022:

- Near collision over Yaizu (January, No. 25)
- TA only mode (May, No. 26)
- No RAs in close encounter (September, No. 27)
- RAs with no loss of separation (September, No. 28)
- Aircraft without operational TCAS (November, No 29)
- Level Off RA not followed (December, No. 30)

All the previous issues are available on SKYbrary at https://skybrary.aero/articles/acas-bulletin-eurocontrol

An updated version of EUROCONTROL ACAS Guide was released in March 2022 (https://bit.ly/ACASGuide). The Guide covers operations of the current TCAS II and introduces the forthcoming ACAS X family of collision avoidance systems.

While ACAS Xa, a new Airborne Collision Avoidance System, is awaiting an approval from European regulators, EUROCONTROL has conducted a validation study (https://bit.ly/3YwrOyw) that indicates that ACAS Xa reduces alert rates by 60% and raises safety by 20% compared to TCAS II. The validation was conducted using the EUROCONTROL Innovation Hub's Collision Avoidance Fast-time Evaluator (CAFÉ) platform (https://skybrary.aero/articles/cafe-evaluator). The platform contains the CAFÉ Revised Encounter Model for Europe (CRÈME) and Collision Avoidance Validation and Evaluation Tool (CAVEAT; https://skybrary.aero/articles/caveat-tool). CRÈME generated millions of close encounters representative of European airspace, while CAVEAT simulated in the cloud the equivalent of billions of flight hours of ACAS interactions.

See also the SKYclip on SKYbrary on TCAS RA not followed (https://skybrary.aero/video/tcas-ra-not-followed). This short, animated video recreates a real-life incident. After an ATC coordination error that put two aircraft on a collision course, TCAS RAs were issued. One of the crews responded in the opposite sense to the received RA, leading to a significant loss of separation.

Would you like to write for HindSight magazine?

HindSight is a magazine on human and organisational factors in operations, in air traffic management and beyond.

As such, we especially welcome articles from air traffic controllers and professional pilots, as well as others involved in supporting them.

Here are some tips on writing articles that readers appreciate.

1. Articles can be around 1500 words (maximum), around 1000 words, or around 500 words in length. You can also share your local good practice on what works well for you and your colleagues, on the theme of each Issue, in up to 200 words.

2. Practical articles that are widely applicable work well. Writing from experience often helps to create articles that others can relate to.

3. Readers appreciate simple and straightforward language, short sentences, and concepts that are familiar or can be explained easily.

4. Use a clear structure. This could be a story of something that you have experienced. It helps to write the 'key points' before writing the article.

5. Consider both positive and negative influences on operations, concerning day-to-day work and unusual circumstances, sharp-end and blunt-end.

If you have an idea for an article that might be of benefit to others,
we would like to hear from you.
Please write to **steven.shorrock@eurocontrol.int**

HindSight

Human and organisational factors in operations

The theme of HindSight 35 will be

JUST CULTURE…REVISITED

HindSight is a magazine on human and organisational factors in operations. The magazine is aimed primarily at operational staff, but also at other practitioners, in air traffic management and beyond. The next issue of *HindSight* will revisit just culture after 10 years since the issue on 'Justice and Safety'.

We welcome articles and short contributions by **Friday 5 May 2023.**

We welcome articles on any aspect of just culture in operations in aviation and other sectors where lessons may be transferrable. We especially welcome articles written by or with operational staff, bearing in in mind that operational staff are the primary readers. Articles may concern, for example:

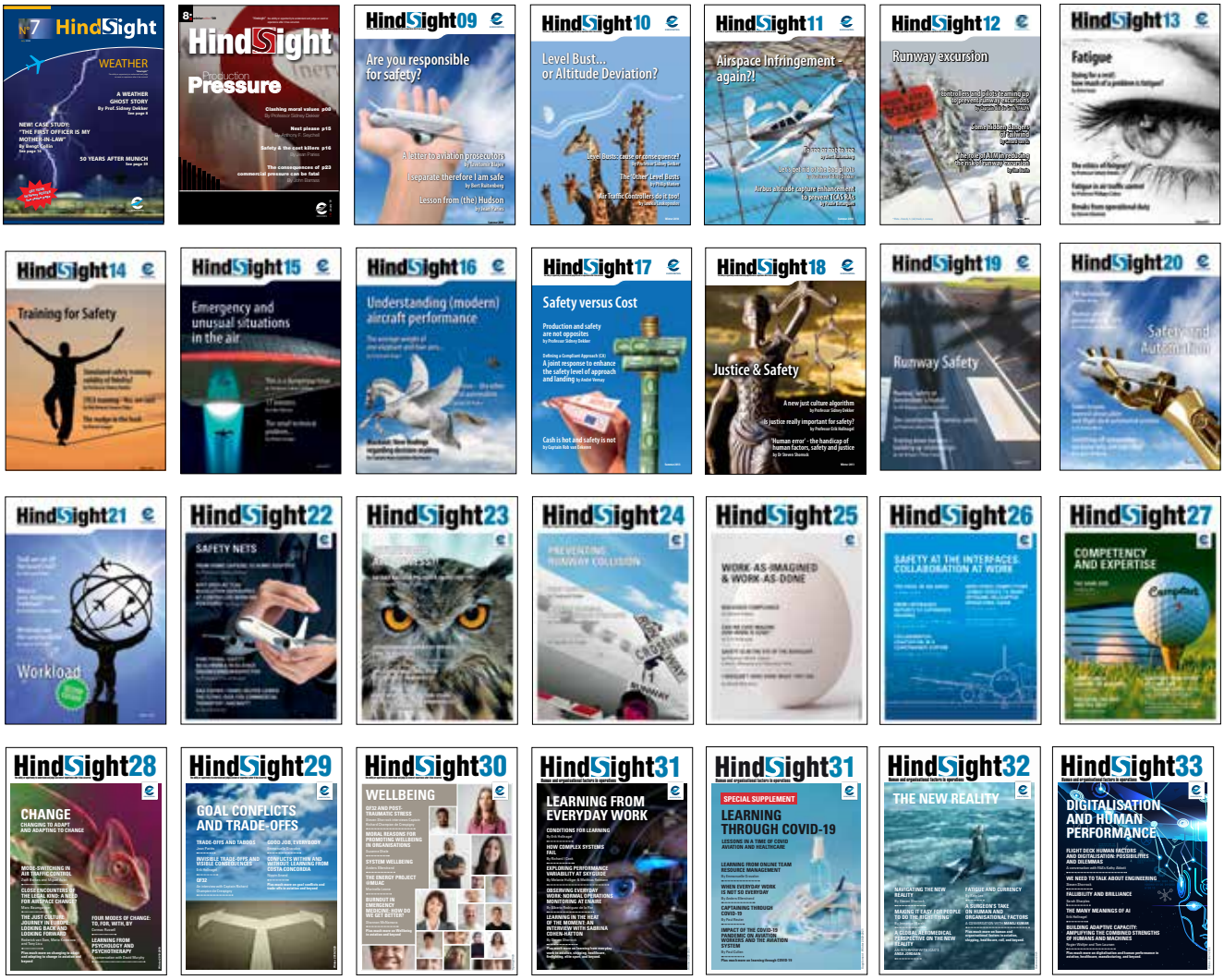
- Just culture at the corporate versus judicial levels
- Regulation and just culture
- Automation, AI and just culture
- Challenges in implementing policies and changing behaviours and attitudes
- Effects of accidents on just culture, including individual and organisational reactions
- Effects of punishment and policies on reporting
- Improving reporting culture
- Just culture and normal operations
- Negligence and criminalisation
- Examples of the benefits of just culture
- Specific national contexts for just culture

Draft articles (1500 words maximum, but may be around 1000 or 500 words) and short examples of experiences or good practice (that may be helpful to other readers) (200 words maximum) should:

- be relevant to human and organisational performance in air traffic management
- be presented in 'light language' keeping in mind that most readers are operational staff in ATM, and
- be useful and practical.

Please contact **steven.shorrock@eurocontrol.int** if you intend to submit an article, to facilitate the process.

If you are interested in downloading back issues of the **HindSight collection**
http://www.skybrary.aero/articles/hindsight-eurocontrol



In the next issue of HindSight:
"JUST CULTURE…REVISITED"

EUROCONTROL