HindSight36

Human and organisational factors in operations

EUROCONTROL

PEOPLE IN CONTROL? STAYING IN THE LOOP

IN, ON, AND OUT OF THE LOOP

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BY STEVEN SHORROCK

PLUS MUCH MORE ON PEOPLE IN CONTROL AND STAYING IN THE LOOP FROM AVIATION, SHIPPING, RAIL, ROAD AND BEYOND.

Autumn 2024

WELCOME

Welcome to issue 36 of EUROCONTROL's *HindSight*, the magazine on human and organisational factors in operations, in aviation and beyond.

This issue is on the theme of **People in Control? Staying in the Loop**. Once again, you will find a diverse set of articles from a range of different authors in the context of aviation, maritime, rail and road. The contributors offer several takes on the intriguing title, from the perspectives of personal experience, professional practice, theory, research, and regulation.

HindSight magazine is all about learning from multiple perspectives on operations, and the related human and organisational dynamics. For this issue, who are the people, and what control do they have, from the 'blunt end' of society and its institutions, to the 'sharp end' of operations? What control should people have? What influences and constrains control? How does technology change human control? How do we 'stay in the loop', and which loops should we be concerned with?

In considering these questions, it is also recommended to review back issues of *HindSight*. The role of people, the changing nature of control, and the difficulties associated with staying in the loop has implications for every issue. Search 'SKYbrary *HindSight*', and think about how this relates to the many back issues.

Thanks to the contributors for their diverse and engaging contributions. Few of the authors are 'professional writers', but all have a passion for communication and particular gifts in getting their message across. And special thanks to the operational reviewers, who help to ensure that *HindSight* magazine is relevant, interesting and useful. Every article is peer reviewed by at least three reviewers (but in some cases up to seven or eight). This presents challenges for editing, but reviewers make every article better in their own unique ways. Reviewers ensure that every article is a good fit for you, the readers. And, of course, thanks to our long-standing cartoonist, who adds a touch of humour and satire with his ingenious creativity, and to our designer, who brings the content alive on the page.

And thanks to you, the readers. While the primary readers of *HindSight* are operational staff, especially those involved in aviation, it is read much more widely, by different people in different sectors, especially those where safety, resilience, and business continuity is critical. 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.

The next issue of *HindSight* will be on the theme of **MENTAL HEALTH IN AVIATION...AND BEYOND** (see inside back cover). We look forward to articles and features on this topic, which is so important to us all.

Steven Shorrock
Editor in Chief

PEOPLE IN CONTROL? STAYING IN THE LOOP

Tony Licu
Head of Technology Division
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EUROCONTROL FOREWORD

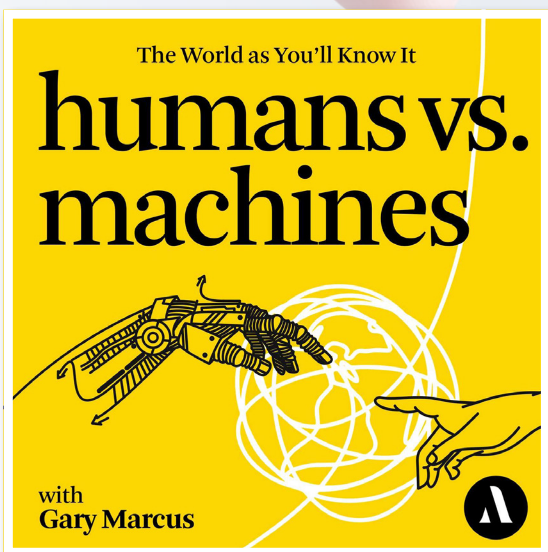
With the explosion of generative AI and large language models, the title of this edition of *HindSight* is more timely and appropriate than ever when it comes to people and technology. I am writing this article a few months after I jumped the fence from safety to technology. I am now in the Chief Technology Officer position at EUROCONTROL and I see how much internal and external pressure we have to start using AI.

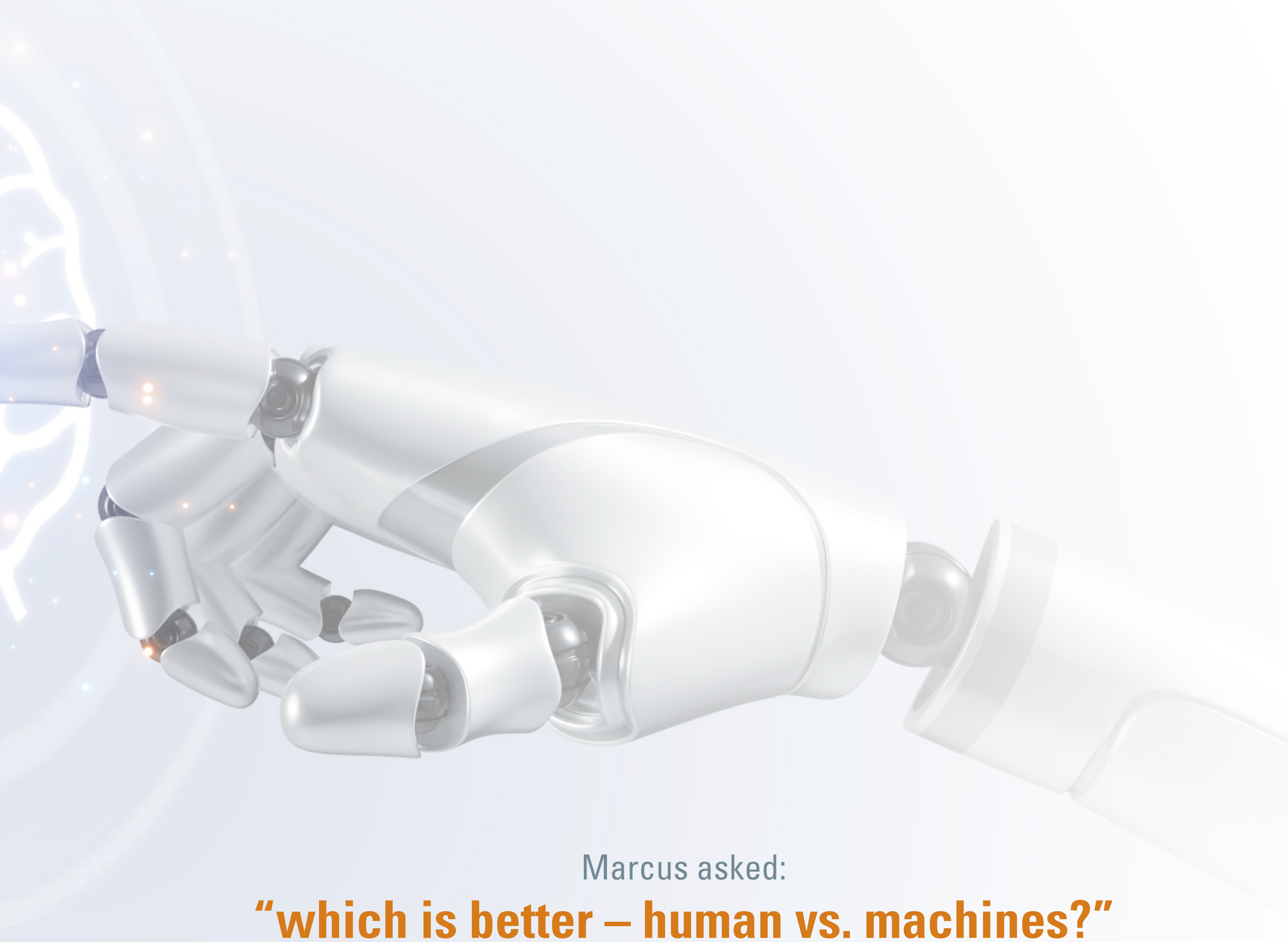
At the time of writing, I am just out of a meeting with Microsoft regarding responsible and ethical AI. They have given a great insight on how to start using AI. First, lay the foundation of governance and then progress to day-to-day usage. When I see how our great minds of 'Eurocontrollers' are jumping immediately on exploring AI it makes me wonder whether the train has already left the station. Perhaps it will be hard to catch up.

The exponential growth of AI poses key questions on how much control we will still have in a not-so-distant future. We see more and more papers, theses and books written with AI. It makes me wonder whether we will reach a tipping point when we read only stuff 'written' by machines? Could there be a new era where humans stop writing? If so, we are at peril because we stop learning.

In aviation and especially in air traffic control, we have always been and felt 'in control'. Air traffic controllers, engineers, and managers felt in control, but seeds of doubt are spreading. An industry that is conservative may overreact and prevent the benefits that AI could bring. But how do we achieve the right balance? Which tools and products should we accept? We have very strict certification processes that require repeatability, transparency and trustworthiness, which may not always be easy to demonstrate when we use AI.

I regularly read a blog of Gary Marcus. His research is at the intersection of cognitive psychology, neuroscience, and artificial intelligence. He recently wrote that: Generative AI is "*a kind of alchemy. People collect the biggest pile of data they can, and (apparently, if rumours are to be believed) tinker with the kinds of hidden prompts... hoping that everything will work out right.*" He suggests that we need "*altogether different technologies that are less opaque, more interpretable, more maintainable, and more debuggable - and hence more tractable - remains paramount.*"





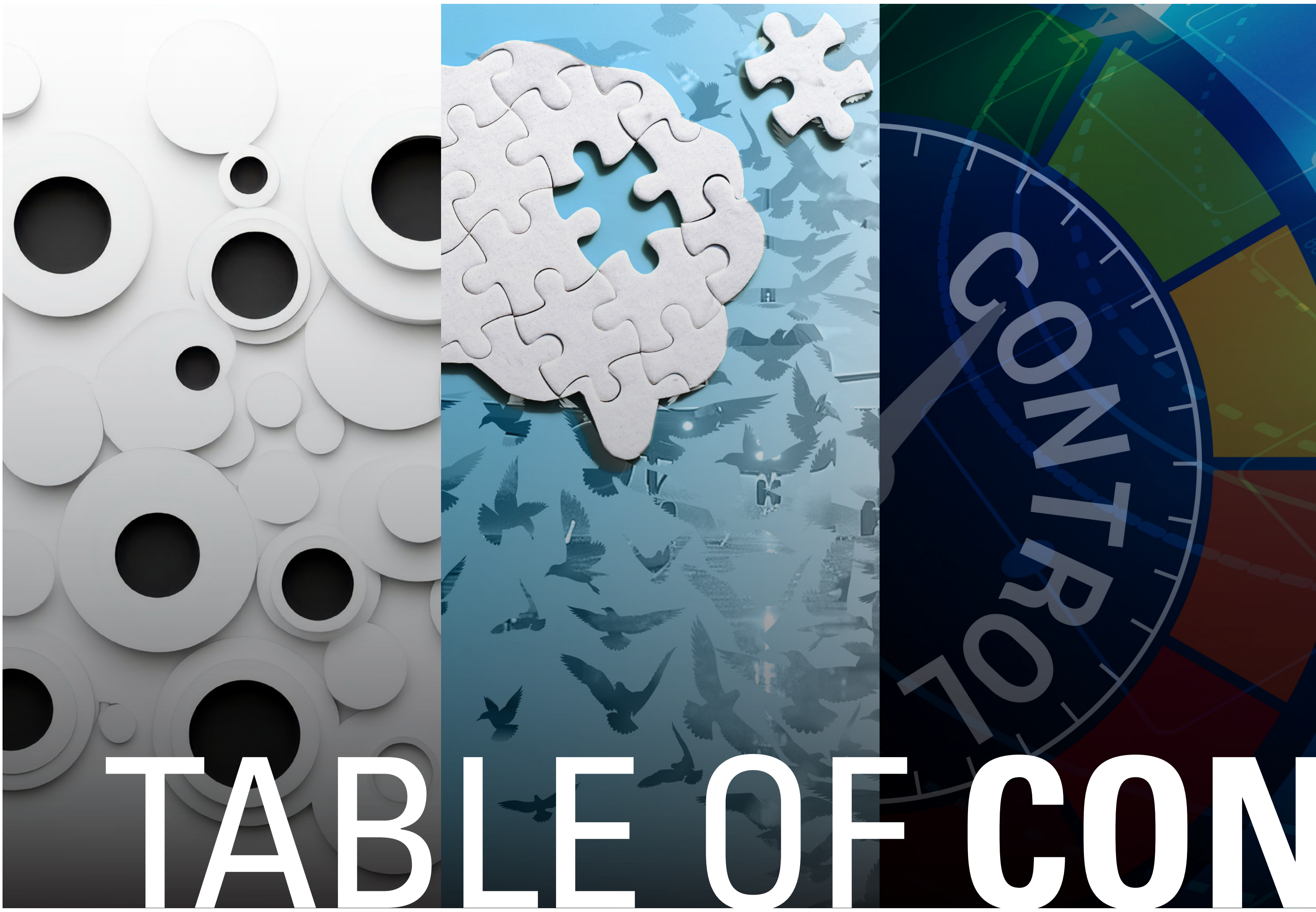
Marcus asked:

"which is better – human vs. machines?"

Marcus asked which is better – human vs. machines? "*Many people think that the human mind is the apotheosis of cognition. I don't*", he recently wrote. He doesn't worship the human mind when it comes to thinking; we have many flaws. Marcus thinks that AI should not aspire to replicate the human mind, but to supplement us, where we are cognitively frail, and to help us, for example, with jobs that are "*dull, dirty, and dangerous*".

I am, however, an incurable optimist, and I think we are still and will still be ahead of machines. Humans still perform well on many things that AI is still poor at. But yes, we have flaws. Eventually, we will find a balance and a partnership. At the moment, we are still trying to work out how to stay in control, while giving increasing control to AI. The sooner we realise that humans and machines are different, each with important roles, the better.

But the issues involved in being in control and staying in the loop go far beyond 'people vs machines' arguments. It is about how we work day-to-day, not only in human-machine systems but as teams, organisations and industries. How do we communicate and collaborate, formally and informally? How can we remain vigilant and prepared? How can we avoid the unwanted effects of surprise? These are old issues, and have been covered in previous issues of this magazine, but are as important today as they ever were, or even more so. These are some of the questions that will be explored in this issue of *HindSight* on People in Control.



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HindSight is a magazine on human and organisational performance in air traffic management and aviation, as well as other sectors. The success of this publication depends on you. Please tell us what you think. And even more important, 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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Alex Bristol
CEO Skyguide

When I think about 'staying in the loop', three different perspectives come to mind. As a former controller, the first and most obvious one is how the controller makes sure that she or he is still in the loop of what's going on in a dynamic operational situation. Working in busy London airspace on Heathrow approach, I remember clearly the feeling of being in the loop in terms of the operational situation, and my need to be in the loop. We had many techniques to stay in the loop and therefore to stay in control. These were passed on from controller to controller. Things still work that way today, and much of it is based on the systems, procedures and training we have built in over decades..

The second thought about staying in the loop is about how we design our future technology. One of the core goals of our work today is to balance the unique strengths of human controllers with the strengths of technology. This isn't a new dynamic, but it's becoming more nuanced as technology offers new capabilities to improve how humans and machines work together.

So when we think of staying in the loop, it's not about removing people but about keeping them connected in ways that let them use their expertise more effectively. A lot of this comes down to how automation is designed. Before I joined skyguide, I saw at NATS how the iFACTS project delivered benefits for controllers and the organisation. The iFACTS support tools allowed controllers to handle more traffic comfortably and safely, providing controllers with decision making support while highlighting potential future aircraft conflicts. iFACTS enabled controllers to look ahead to test the options available, and gave more time to make decisions. In projects at Skyguide, we've followed the same approach, a great example being our stripless system.

"As a CEO, my role is to stay in the loop by listening and learning from the people doing the work. Senior managers must stay in the loop by going to the sharp end regularly to hear from controllers, engineers, and others about what they're experiencing."

The key point for me is that controllers were in the loop of the design process from the very start. By engaging controllers in this way, automation is not imposed on them. Instead, they're helping shape the tools they'll eventually use. Automation must not be something done to them: it's something done with them. This is essential for building trust and for creating systems that fit well into real-world operations.

In Skyguide, I saw the impact of this collaborative, co-design approach again recently during a simulation exercise where controllers managed unfamiliar airspaces with the support of new software. Geneva controllers managed Zurich airspace, then Zurich controllers managed Geneva airspace. Some were sceptical at first, feeling certain it wouldn't work, but by the end, they told us, "Actually, this could work." They were able to adapt because the system was designed with the expertise of controllers who had foreseen many of the practical challenges and opportunities. To me, this is the essence of staying in the loop: designing technology that genuinely supports people rather than taking their place.

As we look forward, with increasing traffic levels, we will likely reach a point in air traffic control where automated systems have a greater role in routine operational safety, just as automated systems can hold a plane steady when conditions are stable. On the ground, air traffic controllers today cannot step back in the same way. Automation should not only keep people in the loop; it should also allow them to step in when necessary. In our field, this is not just a safeguard; it's an expectation. Today's society is reassured when humans are still a central part of the process. But this is a design challenge.

A third critical aspect of staying in the loop is building strong connections among the people within our organisations. Safety-critical roles depend not only on the quality of the tools but also on the communication among teams and in the organisation. We rely on both formal and informal channels to keep everyone aware of the current state of operations. It's essential that controllers and engineers feel safe to report issues, trusting that their voices will be heard. This openness underpins a lot of what we do.

As a CEO, my role is to stay in the loop by listening and learning from the people doing the work. Senior managers must stay in the loop by going to the sharp end regularly to hear from controllers, engineers, and others about what they're experiencing. Sometimes this feedback comes through informal channels – direct messages from employees telling me, "I don't think you know about this, but you should." These messages can uncover issues that might be lost in middle management, but they're critical. I consider these insights one of the greatest gifts anyone can give me because they bring us closer to the real experiences and concerns of our team. They help untangle 'work-as-imagined' from 'work-as-done'.

In our industry, staying in the loop is as much about human-human connection as it is about people and technology. While automation provides powerful support, it's the people in the loop who bring judgment, adaptability, and a sense of responsibility that machines cannot replicate.

We all need to be involved in balancing and connecting these loops. That's the only way to keep air traffic management strong and meet the needs of everyone involved.

Alex was born in 1968 and educated in the UK; he has a Swiss mother and British father. He obtained his private pilot's licence in 1986 and his ATCO licence in 1996 (Heathrow approach), after studying French and German at Exeter University. He moved around a number of NATS sites from 2003 until 2009, being in charge of air traffic services at Farnborough Airport, Manchester Airport and Area Control Centre, West Drayton Centre (where he oversaw the move of the centre and its associated 500 families to the south coast of England), and Swanwick Centre. In 2009, Alex became Director Strategy and Investment and later also Director International Affairs. In July 2011 he left NATS to take up the role of Chief Operating Officer at skyguide, Switzerland. He was appointed CEO of skyguide from 1 July 2017. He is passionate about safety and finding ways to innovate in ATM to improve the customer experience , and to leverage true diversity to improve our services. Alex lives near Geneva with his wife and son.

"In our industry, staying in the loop is as much about human-human connection as it is about people and technology."

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Steven Shorrock
Editor in Chief of *HindSight*

SEEING THE PEOPLE IN CONTROL

I joined the world of aviation in the late 1990s as a Human Factors analyst in air UK traffic management. I had just completed my master's degree in work design and ergonomics, following my bachelor's degree in applied psychology. For the first half of my career, my focus was mostly on micro interactions: breaking down tasks, procedures, and interactions at a granular level – seconds and minutes, button presses and radio transmissions. This work involved incident analysis, critical incident interviewing, human-machine interface evaluation, and simulation observation, all aimed at identifying episodes of what we might call 'loss of control'. Breakdowns and breakages in countless human-human and human-machine loops preceded interactions that sometimes led to losses of separation, level busts and runway incursions.

Looking back, I was primarily using applied cognitive psychology and cognitive ergonomics to understand control through loops of internal mental processes – perception, memory, attention, and decision-making – along with interactions, and feedback and from the environment. This is often depicted in diagrams with boxes and arrows illustrating the processing of information.

In the second half of my career, my work shifted toward the macro level, zooming out to interactions within and between organisations, over months, years, and even decades. I listen carefully to people in various roles about their unique experiences. Here, the loops involve communication, cultures, and changes over time. These loops are inseparable and interdependent, creating formidable complexity in terms of people, technology, processes, structures, and organisations.

No single frame of understanding suffices; I draw upon many disciplines, especially humanistic and social psychology, systems thinking, complexity science, and the humanities, in my attempts to understand the world. From this perspective, people seek to maintain control collectively through loops of communication and influence that evolve before we can even attempt to describe and document them.

Looking at the big picture, what is incredible is not that we sometimes lose control, but that we manage to maintain control at all. (Note that there are various meanings of 'control', from hard – making something happen – to soft – managing or influencing a process or situation – and it is worth thinking about what it means for you.) This brings me to a question that I often pose to groups, including senior managers: If you had to explain to a neighbour why your organisation is so safe, and generally works well, what would you say? The responses vary, but in the best-connected environments, different groups – controllers, engineers, managers, safety specialists – recognise and acknowledge each other's contributions, forming large, interconnected loops. It's a vital question to ponder, because if you don't, how do you know what to nurture and extend…or defend in the face of cost cuts?

"Looking at the big picture, what is incredible is not that we sometimes lose control, but that we manage to maintain control at all."

I recently posed this question to an audience of CEOs and safety directors at a EUROCONTROL conference in Spain. It was heartening to hear some senior leaders acknowledge in detail how people are their organisations' greatest assets. They emphasised that people need to be in control and in the loop. I was surprised at the level of resonance with the theme of this issue of *HindSight*.

The CEOs' comments took my mind back to a groundbreaking report by Charles Billings, Human-Centered Aviation Automation: Principles and Guidelines, published in 1996 by NASA. Billings was a former flight surgeon and specialist in aviation medicine, who became an influential and distinguished NASA expert in aviation human factors. The principles in his report remain solid to this day, and the first three are so general that they apply regardless of the presence of automation.

1. The human operator must be in command.
2. To command effectively, the human operator must be involved.
3. To remain involved, the human operator must be appropriately informed.

The remaining principles focus on the relationship between human operators and automated systems:

4. The human operator must be informed about automated systems behaviour.
5. Automated systems must be predictable.
6. Automated systems must also monitor the human operators.
7. Each agent in an intelligent human-machine system must have knowledge of the intent of the other agents.
8. Functions should be automated only if there is a good reason for doing so.
9. Automation should be designed to be simple to train, to learn, and to operate.

While these principles remain valid, they primarily address the operator-machine dynamic, or 'joint cognitive system'. This was the focus of my interest in cognitive psychology and cognitive ergonomics. But the humanistic psychologist and systems thinker in me seeks principles that recognise people as more than operators, with control (or influence) distributed throughout organisations, industries, and societies. To this end, I propose the following nine principles to help 'see' the people in control:

1. **People are whole and complex beings.** We are greater than the sum of our mental, emotional, or behavioural 'parts', and cannot be fully understood by focusing on tasks, functions, roles, or occupations.
2. **People have unique virtues, values, gifts, and passions.** For these to be expressed fully, we need a supportive and nurturing environment that values individuality, diversity, and inclusion.
3. **People have goals, and seek meaning, purpose, and creativity.** We often seek these things through relationships, work, and personal pursuits.
4. **People naturally strive to learn, grow, and develop.** We tend to flourish in a supportive and enabling environment.
5. **People are inherently social beings.** We seek meaningful connections with others to find belonging, identity, support, and shared purpose, and are profoundly influenced by social norms, expectations, and pressures.
6. **People's subjective experience is unique.** Our experience shapes how we interpret and respond to the world around us and affects our wellbeing.

7. **People live in unique and dynamic contexts.** These ever-changing contexts – personal, social, organisational, societal, political, environmental, technological, economic, and legal – strongly influence us.
8. **People are part of complex adaptive systems.** Our interactions are influenced by a dynamic network of interactions, which are interconnected and interdependent, with outcomes that are often unpredictable.
9. **People have some choice, control, and responsibility.** But agency is distributed among many and shaped by the opportunities and constraints of the contexts in which we exist, along with our capabilities and motivation.

These principles remind us that people are more than operators and need to be considered in the broader context. Although these principles have remained valid over millennia, the contexts and the complex adaptive systems in which we live and work (Principles 7 and 8) have changed dramatically, impacting our choices, control, and responsibilities (Principle 9). I encourage you to consider the principles in the light of any activity or change, inside or outside of an organisation.

Over the last quarter of a century, one observation has become increasingly clear: everything is connected. In a complex industry like aviation, we can rarely discuss 'local problems' in isolation. Even the loss of a single individual – who may possess unique expertise – can significantly impact an organisation. This is equally true for the loss of critical resources. For instance, in our conversation in this issue of *HindSight*, Captain James Burnell discussed the effects of losing crew rooms at some airports. I revisited this impact through the lens of the nine principles I have just outlined. When I recently shared this story with another pilot from a different country, he was horrified at the prospect. "*Crew rooms are sacred!*", he said, "*There would be riots!*" Crew rooms are shared resources that help crews to stay in the loop and maintain control and have even broader benefits for people.

Going back to my "*If you had to explain to a neighbour…*" question, my answer is that things work because people make things work, bridging the gaps in the loops as they arise in order to stay in control. We do this using our remarkable expertise, creativity and connectivity, and do this sometimes to our personal cost. What is amazing is that things work as well as they do. It's time that we fully acknowledged the reason for this – us – and respect people as so much more than operators and overseers of machines and processes.

> "Things work because people make things work, bridging the gaps in the loops as they arise in order to stay in control."

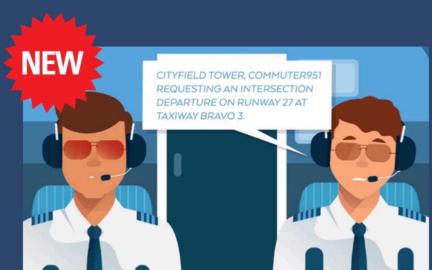
SKYclips

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

- Aimpoint selection
- Airside driving
- Airspace infringement
- Airspace infringement and aeronautical information
- Bird strike
- Callsign confusion
- Changing departure runway while taxiing
- Changing runways
- Conditional clearance
- Controller blind spot
- CPDLC
- Downburst
- EMAS **(new)**
- Emergency frequency
- En-route wake turbulence
- Freezing rain **(new)**
- Helicopter somatogravic illusions
- Immediate departure
- In-flight icing
- In-flight fire
- Landing without ATC clearance
- Level busts
- Low level go around
- Low visibility takeoff
- Mountain waves
- MSAW & incorrect QNH setting **(new)**
- Multiple line-ups **(new)**
- Pilot fatigue
- Readback-hearback
- Reduced TORA
- Runway occupied medium term
- Sensory illusions
- Separation from unknown aircraft
- Separation of arrival and departure during circling approach
- Shortcuts and unstable approaches
- Speed control for final approach
- Startle effect
- Stopbars
- Taxiway take-off
- TCAS - Always follow the RA
- TCAS RA high vertical rate
- TCAS RA not followed
- Unexpected traffic in the sector
- Volcanic ash **(new)**
- Workload management

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

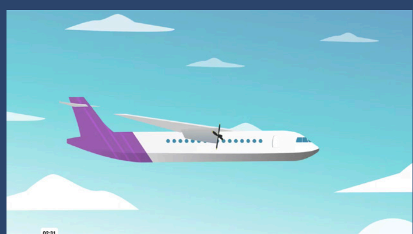


Multiple line-ups

Volcanic ash

EMAS

Freezing rain


In-flight icing


Taxiway take-off

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

Erik Hollnagel

STAYING IN NESTED LOOPS
A SYSTEMIC VIEW

'Staying in the loop' relies on continuous feedback within and between organisations to allow individuals, groups, and organisations to make informed decisions. In this article, Erik Hollnagel explores these 'nested loops', along with the gaps between imagination and reality, with implications for learning, design, training and management.

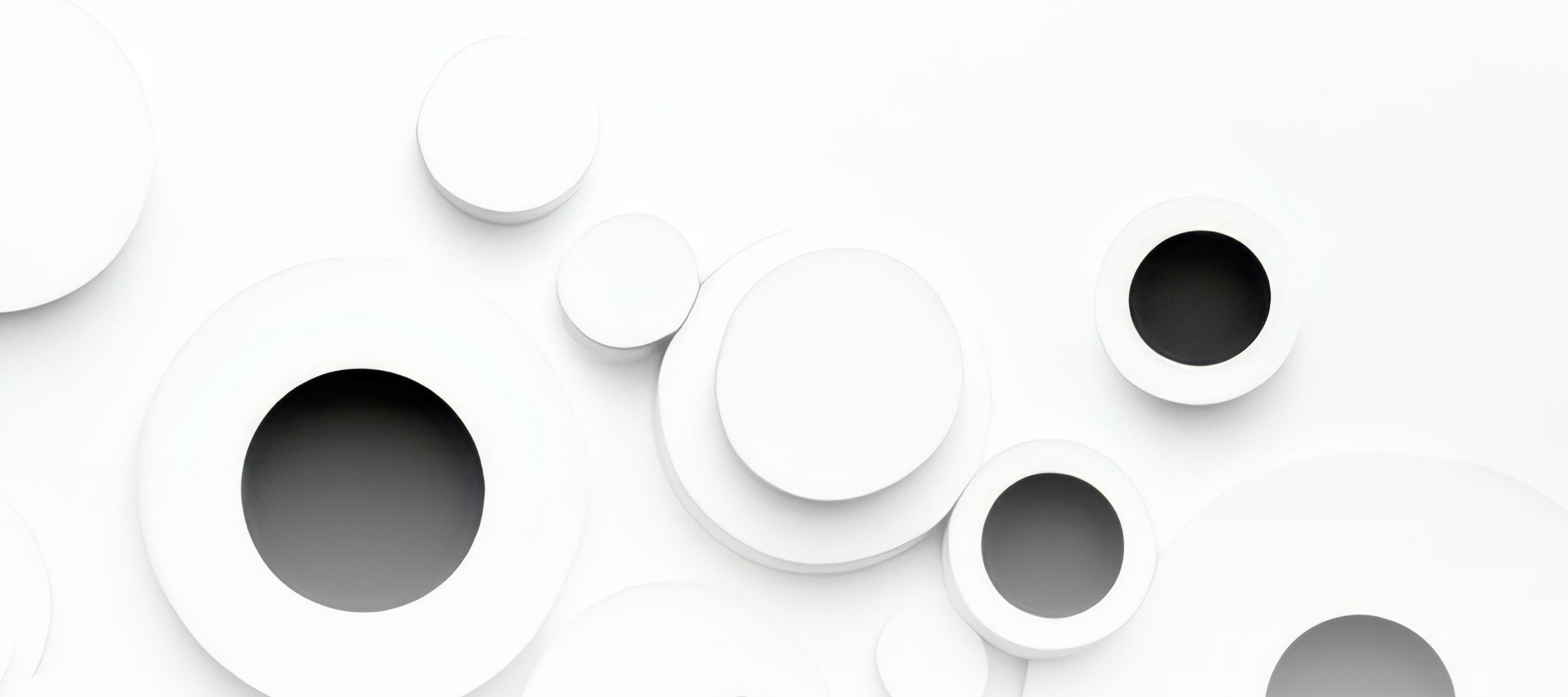
KEY POINTS

- **The 'law of requisite variety':** Effective regulation depends on the regulator's ability to match the complexity of the system it controls. The 'law of requisite variety' states that the regulator must have sufficient variety to handle all possible states of the system, as this is essential for maintaining control.
- **Bridging work-as-imagined and work-as-done:** There is often a significant difference between how work is envisioned by designers, trainers, managers (work-as-imagined) and how it is (work-as-done). Bridging this gap requires the ability to foresee potential future conditions and discrepancies – 'requisite imagination'.
- **Learning from experience:** Effective control relies on feedback and learning from experience. While individuals tend to adapt and learn dynamically, collective (organisational) learning is slower and more limited. Delays and distortions in feedback can impede effective control, making timely and accurate feedback crucial for decision-making at all levels.
- **Continuous feedback:** Staying in the loop depends on continuous feedback inside and between organisations, which enables individuals or organisations to make informed decisions to increase requisite imagination, and reduce as far as possible the gaps between work-as-imagined and work-as-done.

THE SHARP END (OPERATOR) LOOP

To stay in the loop means continuously to receive feedback about how something develops, such as flying an aircraft through a sector or walking through an unfamiliar metropol to find your hotel. Staying in the loop is but also (and more importantly) to be able to use the feedback to choose the appropriate response or intervention, in order to stay on course and remain in control.

Whoever or whatever maintains control is usually called a 'regulator'. A regulator can be an organisation. This is probably how most people interpret the word. Examples of organisations are the Federal Aviation Administration (FAA) in the US and the European Aviation Safety Agency (EASA) in Europe, plus the countless regulatory bodies that permeate modern societies. A 'regulator' can also be a person more generally, such as a pilot in a flight deck or a



controller at a working position. At the simplest level, a 'regulator' can be a simple analogue mechanism. A good illustration of that is the purely mechanical centrifugal 'governor' that James Watt introduced in 1788 to regulate the flow of steam into his steam engines. Prior to that, it had been done manually by an operator (hardly an exciting job). The term governor points to the roots of cybernetics, "*the science of control and communication in the animal and in the machine*" (Wiener, 1948). Cybernetics also formulated a basic principle of control known as the law of requisite variety (Ashby, 1956). This is particularly relevant to this issue of *HindSight* on people in control.

REQUISITE VARIETY

The law of requisite variety (LoRV) simply states that the variety of the outcomes (of a system or a process) only can be decreased by increasing the variety in the regulator of that system. Another way of expressing that is the so-called good regulator theorem (Conant & Ashby, 1970), which states that "*every good regulator of a system must be a model of that system*". We usually refer to our understanding of the target system as a model of that system, although it is rarely a model in the formal sense.

In everyday language, the LoRV simply states that if something happens that the regulator either cannot recognise or cannot respond to, then control will be lost. This is a condition that we all experience from time to time at work and at home, but hopefully not too often. The feedback provides the information that allows us to determine whether the actual state or position corresponds to the intended state or position. We can then use any noted difference to predict the outcome of possible action alternatives and choose an appropriate corrective intervention.

REQUISITE IMAGINATION

The purpose of the 'regulator' is to respond in a way that ensures that the developments being controlled stay on course. When we build a regulator, either a piece of technology or a human ('built' via training), the critical issue is how to ensure the requisite variety.

A major problem here is the difference between work-as-imagined (WAI) (what the designers think can happen; see Shorrock, 2020) and work-as-done (WAD) (what actually happens). To do so successfully requires so-called requisite imagination (Adamski & Westrum, 2003). This was proposed as an analogy to requisite variety. Requisite imagination is the ability to imagine key aspects of the future one is planning or designing.

The difference between work-as-imagined and work-as-done was not a problem for the centrifugal governor mentioned earlier. Here, the requisite variety was limited because the steam engine was a strictly deterministic system. But this difference is a problem for the complex socio-technical systems of today, where the requisite variety is huge, along with the number of things that can possibly go wrong.

"The difference between work-as-imagined and work-as-done is a problem for the complex socio-technical systems of today."

LEARNING AND THE LIMITATIONS OF EXPERIENCE

Requisite variety and requisite imagination are especially problematic for those preparing the training needed to gain the competence required for a specific job, such as a pilot or controller. These requisites are also a problem for writing the procedures that people can refer to and rely on in critical situations. A problem in developing guidelines and procedures is that this is based on the experience from the limited set of events that have happened plus whatever people, procedure writers, designers, and law makers can imagine beyond that. But experience and imagination pales against the potentially unlimited set of events that may happen throughout the system's remaining lifetime, as countless experiences show. This gap between imagination and reality occurs particularly because thinking in terms of single components and failures is insufficient for a world where combinations of conditions and actions are known to play a significant role. (This is why a constitution is never sufficient in itself, but has to be supplemented with multiple amendments.)

In light of these gaps, the solution for people at work is often to depend on their natural ability to learn from experience, in the hope they can recall it when the need arises. This means that the potential to learn is essential for effective control and for staying in the loop.

Being in control can more formally be said to require the four systemic potentials developed by Resilience Engineering (e.g., see Hollnagel, 2009; Hollnagel, Licu & Leonhardt, 2021; Hollnagel, 2025): 1) the potential to respond, 2) the potential to monitor, 3) the potential to learn, and 4) the potential to anticipate).

In practice, people will learn by themselves, and from others, and hence cumulatively improve their requisite variety. But often the control is by an organisation. Organisations can, of course learn (or rather the people in an organisation can learn), but organisational learning is often limited to avoidance learning of what not to do and what to mitigate, defend against, constrain or eliminate. Such learning is furthermore slow and may not be very reliable. While we train people individually and sometimes in teams, we do not yet train organisations, except via the introduction of rules and standards. Instead, we train their leaders in the naively optimistic hope that this somehow will rub off on the organisation.

THE SHARP END AND THE BLUNT END

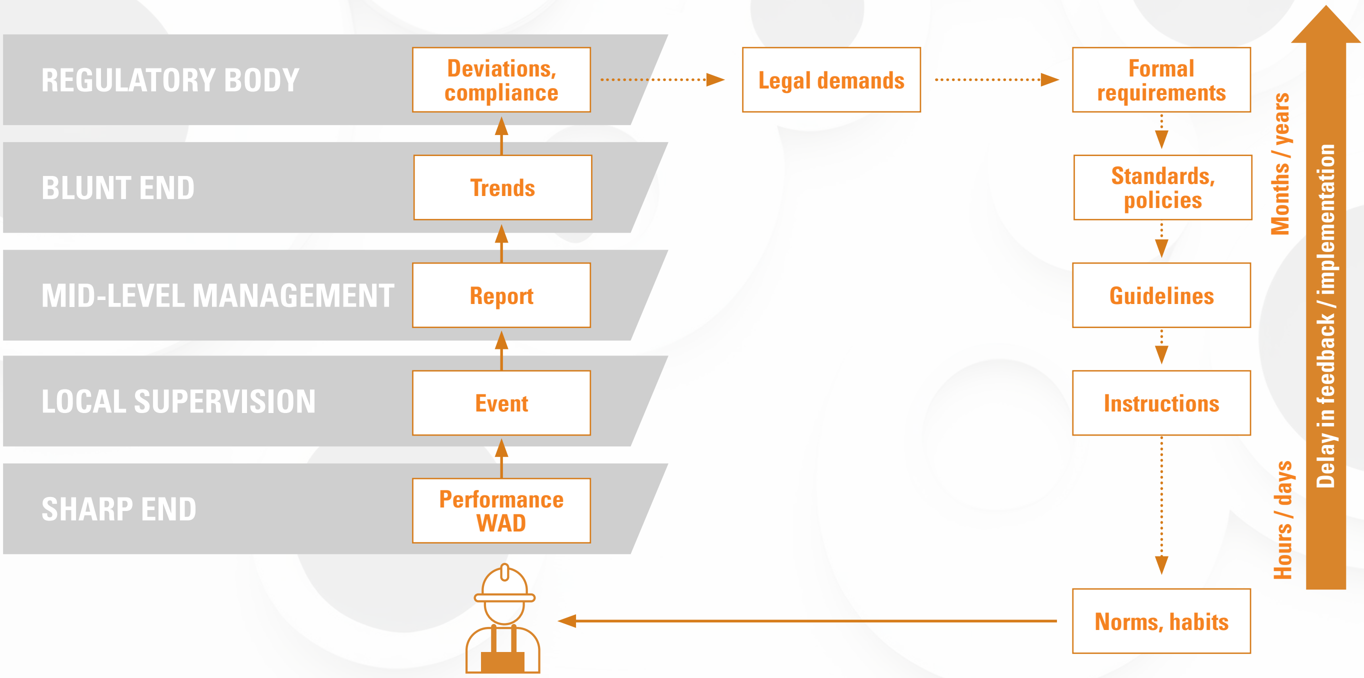
The expression 'to stay in the loop' is usually reserved for people who work at the 'sharp end'. That term was introduced by Reason (1990), although he called it "the front end". The sharp end refers to the people who "*actually interact with the hazardous process in their roles as pilots, physicians, space controllers, or power plant operators*" (Woods et al., 1994, p. 20). In former times they were also referred to as workers at the coalface, and in the context of *HindSight*, they include the pilots in the cockpit.

The work of people at the sharp end must meet criteria and take place in conditions that have been defined by others, who are usually not doing the work themselves (and therefore not directly exposed to any harmful consequences, and who may not even be able to do the work – even if they once did). These people work at the 'blunt end', but as Professor Karlene Roberts cleverly observed, "*everybody's blunt end is someone else's sharp end.*" And just as people at the sharp end must be in the loop to do their work, so must people at the blunt end.

Any complex system, such as air transportation, therefore comprises multiple feedback loops nested within each other (Figure 1). We know from many psychological studies that human performance deteriorates if feedback is delayed. And in this respect, people at the blunt end are clearly at a disadvantage, as described by Figure 1. The information they get about what actually happens (work-as-done) has been filtered and interpreted multiple times in ways that are mostly unknown.

This is why high-level recommendations of a very general nature are often of limited practical value. Add to that a significant delay of months and potentially years to find out whether the recommendations had the intended effect, and it is clear that the managers at the blunt end are not, and cannot be, 'in the loop' as much as they might hope. And the conditions are even worse for a goverment regulator, who faces a nearly impossible challenge.

Figure 1: Multiple nested feedback loops in a complex socio-technical system



CONCLUSION

In conclusion, staying in the loop depends on continuous feedback inside and between organisations, which enables individuals or organisations to make informed decisions. This is made difficult by the delays and distortions that can occur as information moves up the hierarchy and the inevitable gaps between work-as-imagined and work-as-done. Poor feedback forms a challenge to learning, designing and managing, as revealed in the sometimes stark differences between designed procedures (and training) and actual operations.

> "Poor feedback forms a challenge to learning, designing and managing, as revealed in the sometimes stark differences between designed procedures (and training) and actual operations."

The only way forward is to reduce, as far as practicable, the gaps between work-as-imagined and work-as-done, via more collaboration between the so-called sharp and blunt ends, to understand how work is actually done and decide on how it might best be done (to keep the variability of work-as-done within acceptable limits), knowing that this may never correspond to our imagination.

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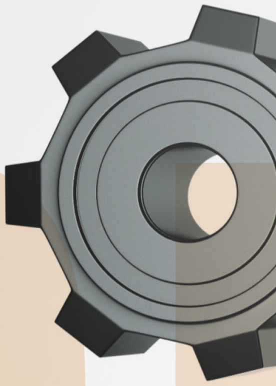
Immanuel Barshi

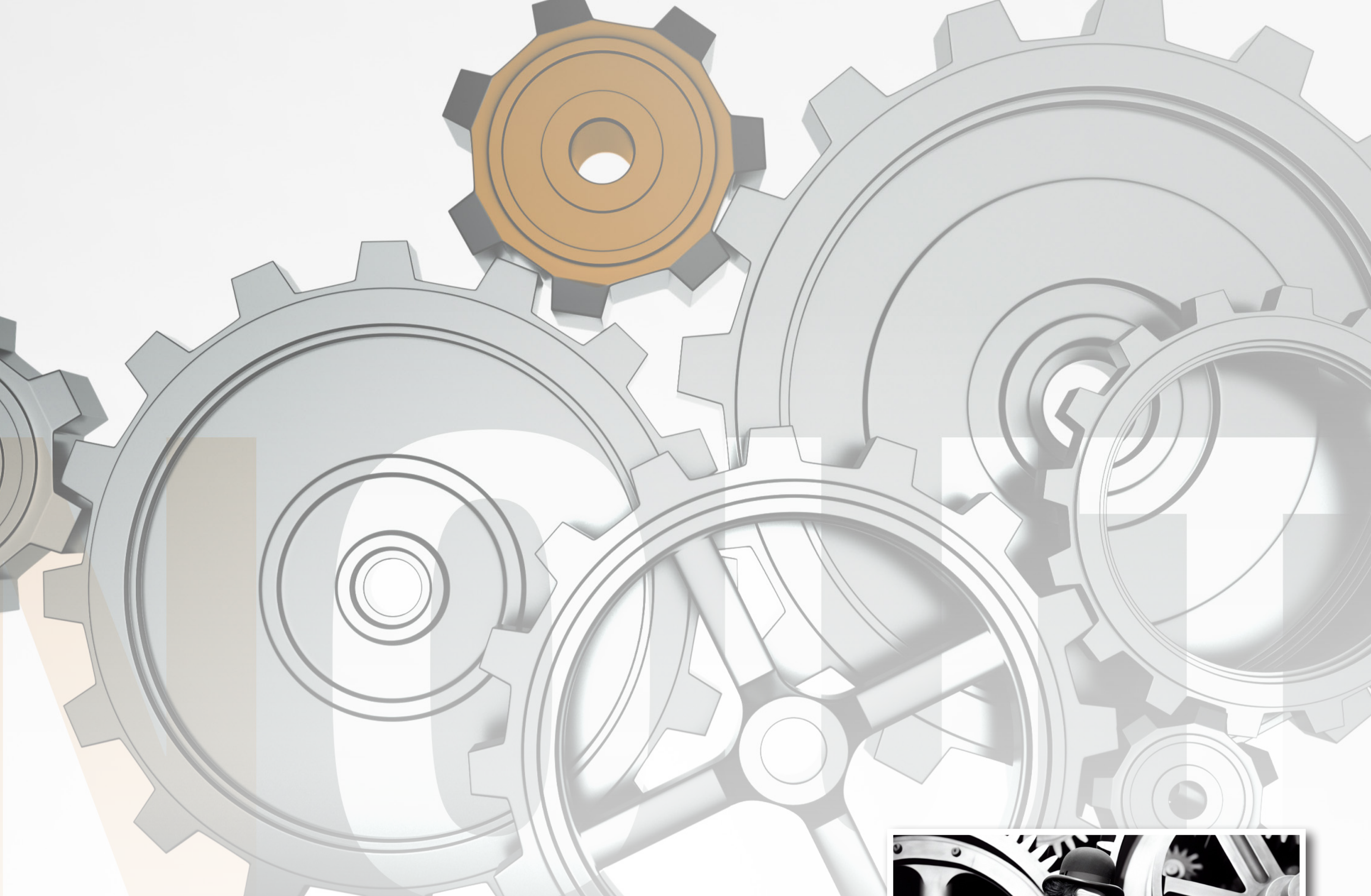


IN, ON, AND OUT OF THE LOOP

As automation evolves, we need to ensure that those overseeing critical systems can effectively transition from monitoring to taking control when it matters most. But some designs do not make obvious the need to intervene. Immanuel Barshi explores the quandary.

KEY POINTS

- **In the loop versus on the loop:** There is a difference between being 'in the loop', where a person has direct control over a machine, and being 'on the loop', where they supervise the automation without direct control. Effective supervision requires readiness to intervene if the automation fails.
- **Automation surprises:** Automation can lead to 'automation surprises', where systems behave in unexpected ways. These surprises can have serious consequences, as seen in historical aviation incidents.
- **Feedback:** There is a need for automated systems to provide clear indications of their states, transitions, and any potential issues. Systems that fail to communicate these effectively can lead to dangerous situations.
- **Training:** Controllers and pilots must receive thorough training to understand the logic and potential pitfalls of automated systems, and to be ready to step in and take control when automation does not perform as expected.



In his 1936 black and white part-talkie film Modern Times, Charlie Chaplin is struggling to stay in the loop with the new automation installed at the factory. He is constantly thrown out of the loop, and in some cases remains in the loop, in some respects, even after walking away from the production line. He is like an air traffic controller who continues to play the traffic in her head after the shift is over to figure out what could have been done better. It seems that not much has changed since the early introduction of automation. One small change did happen: Charlie Chaplin didn't have the experience of being on the loop.

We talk about being in the loop when we have direct control of the machine. Driving a manual transmission car in busy stop-and-go traffic during rush hour in the city keeps us in the loop of controlling the car. Executing a series of aerobatic manoeuvres in a 1945 Pitts Special keeps us in the loop of controlling the biplane. And constantly giving takeoff and landing clearances at a busy airport keeps us in the loop of controlling the traffic. We know exactly where every aircraft is and where we want it to go, and we keep monitoring to make sure it gets there.

"We talk about being in the loop when we have direct control of the machine."

We talk about being out of the loop when we have no control of the machine, or even when we have no feedback on how the automated controller is managing the machine. We fill the coffee maker's reservoir with water, make sure there are coffee beans in the hopper, place a cup under the brewing head, set the timer to have a cup of coffee ready when we wake up the next morning, and go off to bed for the night's sleep. We have no direct control of the machine's internal algorithm. Hopefully, the smell of fresh coffee drifts into the bedroom just as the alarm clock goes off to wake us up. We have been sleeping peacefully out of the coffee-making loop all night. Some Tesla drivers have been sleeping peacefully out of the car-driving loop travelling at a constant distance behind the car in front of them, according to the setting of their adaptive cruise control, while their lane-centring algorithm gently follows the curves in the road, careful not to wake them up.

"We talk about being out of the loop when we have no control of the machine, or even when we have no feedback."

Charlie Chaplin in Modern Times (AI generated)

Similarly, airline dispatchers increasingly rely on neural network or deep learning programs that spit out flight plans based on optimal winds, aircraft weight, temperature, traffic density, landing slot time, crew duty periods, passenger connection times, and many other variables. This is mostly opaque to the dispatcher and places them out of the loop.

When we know how to work the machine, staying in the loop is easy (if the machine is designed to allow us to do that).

When we don't need to care about the machine's behaviour, staying out of the loop is easy.

Charlie Chaplin may not have known it, but it was a good choice not to work into his film the experience of being on the loop. That's the tricky one.

We talk about being on the loop when we assume a supervisory role, when our only job is to make sure the automation does what it was designed to do. Of course, there is a minor catch to that seeming luxury. If the automation fails in some way, we need to be able to jump in and intervene so the operation can continue to flow smoothly.

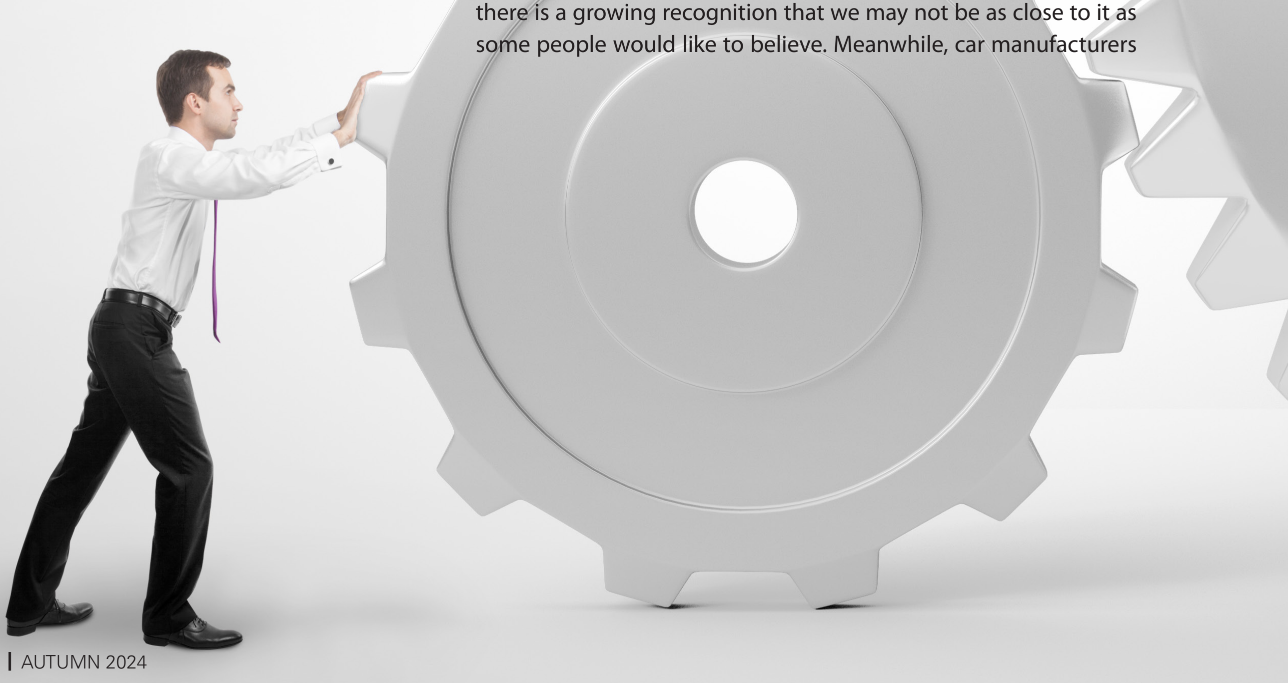
"We talk about being on the loop when we assume a supervisory role, when our only job is to make sure the automation does what it was designed to do."

Imagine having to supervise the coffee maker through the night. Chances are, you won't get much sleep. If the coffee-making machine was designed to be supervised, it would have to have some indication letting you know what state it is in. You would have to be trained to know the precise sequences of states it can go through in the process of making the coffee so you'd be able to predict when it is likely to transition to the next state and under what conditions it might fail to do so. You might be able to set your alarm clock to wake you up just before a transition takes place so you can confirm that it did it right. You might even suggest to the designers of the coffee maker to integrate such an alarm clock into the design of the coffee maker. In fact, the designers of aircraft's flight management systems (FMS) tried to do exactly that when they envisioned the role of the pilot as one of being on the loop rather than in the loop.
The FMS uses the FMA (flight mode annunciator) to indicate to the pilot the state that the aircraft automation is in, and in some cases when transitions occur between states (e.g., 'altitude capture' as the aircraft transitions from a climb to level flight at the assigned altitude). Airlines invest tremendous effort training pilots to understand and to know the sequences of states involved in flight and the transitions between them so pilots can successfully supervise the automation to maintain efficient and safe flights. As we know, that doesn't always happen.

For instance, the downing of Korean Airline flight 007 in 1983 was likely the result, in part, of the pilots not recognising the fact that their Boeing 747 remained in 'heading mode' and did not transition to 'navigation mode'. Unfortunately, this 'automation surprise' ended up in a far more serious surprise (see Degani, 2004, for an analysis of this accident as well as similar problems with various machines and different modes of transportation).

The aviation research literature is filled with discussions of such 'automation surprises'. These are situations in which the automation behaves in ways the operator – or rather, supervisor – did not expect and did not anticipate. From the early days of aviation's advanced automation (see, e.g., Wiener, 1989) through the mid-90s (see, e.g., Sarter and Woods, 1995) and all the way to the very present (see, e.g., Dekker and Woods, 2024), we continue to struggle with the supervisory role. In particular, we struggle with the timely transition from being on the loop to being in the loop.
Dekker and Woods (2024) describe some automation as being "strong, silent, and wrong". Their work is an important call for designers to at least eliminate the "silent" part, if they design the automation to be strong, recognising that we can't eliminate all the possibilities of the automation being wrong. It is exactly when the machine is silent that we don't know when it's time for us to intervene.

With new technologies, with the push for autonomous vehicles, and with the growing number of semi-autonomous features in cars, we see a growing research literature on the need for drivers to transition from being on the loop to being in the loop (see, e.g., Merat et al., 2014). The idea of truly autonomous vehicles is to keep the driver – sorry, passenger – completely out of the loop, but there is a growing recognition that we may not be as close to it as some people would like to believe. Meanwhile, car manufacturers



integrate various systems to alert the driver to stay closer to the loop, if not in the loop. Some cars have sensors in the steering wheel to make sure the driver's hands are on the wheel even if the lane-keeping and lane-centring features are engaged. Some cars have eye-tracking cameras that alert the driver if their eyes are off the road for more than a few seconds, or if their eyelids droop as a sign of possible sleepiness. But it's unlikely that ATC equipment manufacturers will integrate such features into their designs, and the increasing popularity of AI algorithms only raises more challenges (see, e.g., Mazzolin, 2020). And so the struggle to stay close to the loop while on the loop, and to know when to jump in and intervene, will remain with us for the foreseeable future. So what can we do?

On the design side, we need our systems not to be silent. We want clear indications of states, of impending transitions, and of any situations in which the conditions necessary for such transitions do not obtain. We'd like our systems to 'communicate their intentions' so we know what to expect and are not surprised.

On the controller's side – in the absence of better design – we must invest in good training and good support materials that enable controllers to understand their systems, including the logic and rationale of their design. This should help controllers to know which machine state is the right state for a given traffic and environmental situation, and to be prepared to jump in on short notice if anything looks out of place. To be able to do that, one must know what's the right place for every piece of the current ATC picture. And one must maintain a state of mind I call 'proper paranoia', recognising that despite the very high reliability of the machines and automated systems we work with, they may behave in an unexpected way any minute and with little, if any, warning.

By building systems that are sensitive to the challenges of holding operators on the loop, designers can support us better. By maintaining proper paranoia, controllers and other frontline operators are better able to hold that on the loop position. As the accident record shows, the space between in the loop and out of the loop is fertile ground for us all to better ourselves and our systems for the sake of safety.

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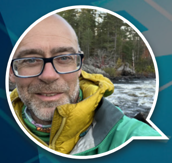

Tab Lamoureux Chelsea Kramer Catherine Dulude

"MANAGE THE GREEN"

OBSERVATIONS OF HOW CONTROLLERS STAY IN CONTROL OF TECHNOLOGY

In the Canadian air traffic management system, controllers work with cutting-edge technology to stay in control. Tab Lamoureux, Chelsea Kramer and Catherine Dulude observed and interviewed controllers to better understand how they stay on top of technology, resulting in five key insights.

KEY POINTS

1. **Automation and cognitive capacity:** Controllers use automation to free up cognitive capacity, allowing them to handle more aircraft and complex problem-solving tasks efficiently.

2. **Understanding how the technology works:** Controllers need to understand the underlying mechanisms of technological systems to an appropriate level to interpret alerts accurately and maintain system integrity.

3. **The role of continuous interaction:** Maintaining control involves continuous interaction with display objects, systematic scanning, and active confirmation of automated functions to synthesise data into a coherent operational picture.

4. **The importance of visual scanning techniques:** Despite technological advancements, traditional scanning techniques remain essential, helping controllers understand what's going on and identify potential issues.

5. **Understanding the airspace and traffic flows:** Controllers' deep understanding of airspace dynamics and predominant traffic flows allows them to anticipate and respond effectively to operational challenges.

INTRODUCING THE CANADIAN ATM SYSTEM

Although the Canadian air traffic management (ATM) system infrastructure and the associated human-machine interfaces have been in use for many years, the current system remains one of the most functionally advanced in the world. The system has kept pace with increasing traffic volumes and complexity, accommodated advanced decision support and automation, and supported the highly varied and unique challenges of our airspace. With the sometimes subtle changes that have occurred over the years, we wanted to know how controllers stay in the loop. Since the system as a whole remains human-centred, with people in control, it is important to understand from controllers what they do to stay on top of the technology. Such insights help to shape the next generation of ATM systems to ensure that the human-automation partnership is mutually effective.

To get a better understanding of this issue, we observed and spoke to eight controllers in four units. The approach to both observations and interviews was unstructured and opportunistic. After explaining our interest in how they keep on top of, or ahead of, the automation, controllers described their strategies. We then probed further based on what the controllers said. In this article, we summarise five ways in which controllers stay in control based on what we saw and heard.

> "Controllers felt that well-designed automation can help to free up time and capacity to handle more aircraft and yet still have spare capacity to deal with more complex problem-solving activities."

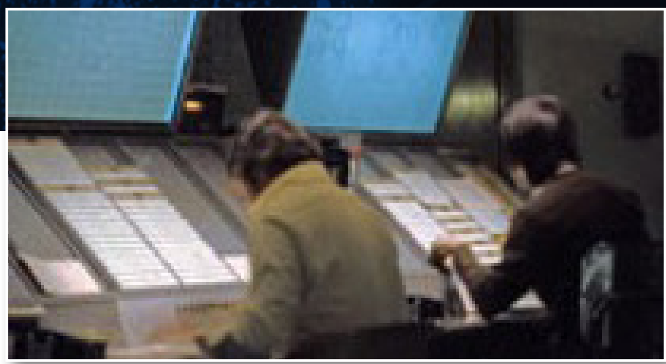

Figure 1: North Atlantic Control Position - Then

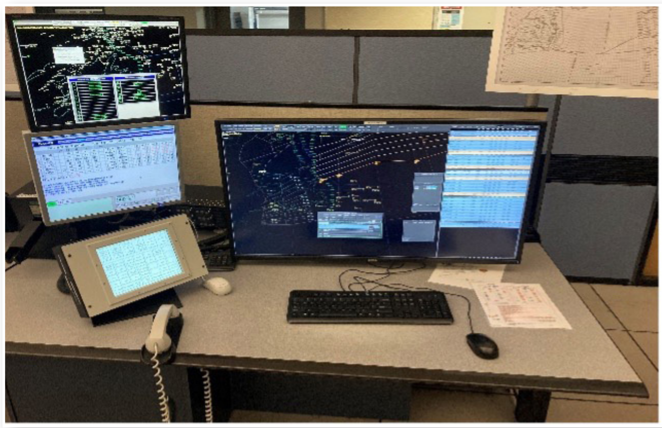

Figure 2: North Atlantic Control Position - Now

1. STAYING IN CONTROL MEANS ALLOWING AUTOMATION TO FREE UP CAPACITY

Controllers felt that well-designed automation can help to free up time and capacity to handle more aircraft and yet still have spare capacity to deal with more complex problem-solving activities. This includes time to scan the situation display, identify conflicts and find route efficiencies.

Prior to the integration of today's advanced technology, more time was spent planning and attempting to work 'ahead' of the traffic. Automation and associated alerts now provide appropriate warning of events that controllers need to be aware of. Controlling aircraft today involves more validation of information with a shorter time horizon than previously.

For instance, CPDLC (controller-pilot datalink communication) and space-based ADS-B (automatic dependent surveillance–broadcast) are key enablers over the North Atlantic. These technologies permit communications and surveillance where previously procedural control had to be used. The ATM system presents all information on a single display, showing a mix of extrapolated and surveillance targets. The system determines what separation must be applied and then provides the controller with notifications (and warnings if necessary) for flights. This has resulted in a change in this unit's style of controlling. Previously, controllers would work from the strips to the situation display. Now, because surveillance is the norm, controller attention is focused more on the situation display than on the strips.

As well as tactical control over the ocean, this unit is responsible for planning traffic onto the ocean. Conflict-free profiles are employed so that, if no communication were possible, all aircraft would remain separated for the duration of the route. The complex planning task is now aided by automation; specifically, a problem-solving and decision support tool that reduces demand on working memory, mimicking the manual tools used by controllers.

As another example, in some Canadian airspace, the lack of communication and surveillance coverage can mean that a controller needs to apply a variety of separation standards across their sector. To manage this challenge, the flight data processing system and associated controller tools are arguably the most highly adapted in the country, automatically anticipating the most likely controller input, validating other controller inputs, and prompting controllers when a different strategy needs to be employed. Controllers now routinely control far more aircraft than in the past with very high levels of trust in the technology.

2. STAYING IN CONTROL MEANS UNDERSTANDING THE SYSTEM

Appropriate trust in, and use of, technological systems means that controllers need to understand, to an appropriate level, the underlying technical system. The controllers all expressed a need to understand how the system works and what the automation is trying to tell them. Training provided to controllers teaches them what information is going into the technology and how to clarify any ambiguity. They are trained to always take warnings seriously. Here, the concept of 'display hygiene' is important; system messages are not left to persist in an elevated alert state. Controllers are taught to include system message lists in their active scan and will physically mouse-over the list with the cursor.

> "The controllers all expressed a need to understand how the system works and what the automation is trying to tell them."

Overconfidence can creep in, so good operational habits should be constantly reinforced. An appreciation of common decision-making heuristics and biases that can affect operational performance with automation may help to maintain human performance. Such threats to human performance have been described as "ironies of automation" and "ironies of artificial intelligence" by Bainbridge (1983) and Endsley (2023).

3. STAYING IN CONTROL INVOLVES CONTINUOUS INTERACTION

Another finding from the study was that staying in control involves continuous interaction, not passive monitoring. This may include:

- systematic interaction with display objects via the mouse, and
- 'display hygiene' activities (e.g., acknowledging system alerts/ messages, confirming that automated functions have been successfully completed).

This physical activity could be observed in controllers and was critical to the synthesis of flight data into a coherent mental picture of the operational situation. This takes us to scanning.

4. STAYING IN CONTROL MEANS KNOWING HOW TO SCAN

Although the job is changing, experienced controllers felt that new controllers should continue to be taught scanning, as has been done for previous generations. This is an active and engaged habit based on a good understanding of the airspace, deliberately searching for and selecting information to build a strong understanding of the dynamic situation. Continuous and deliberate scanning requires effort and discipline, especially when scanning includes information derived from automation.

> "Experienced controllers felt that new controllers should continue to be taught scanning, as has been done for previous generations."

Controllers exhibit a number of different active scanning strategies. These include:

- identifying clusters of aircraft that might need some intervention
- identifying other sources of complexity (interactions between aircraft, special use airspace or overtaking which could result in turbulence)
- 'looking for green' or other unusual colours (green means an aircraft is available for communication and control)
- scanning outside the sector for aircraft that will arrive shortly
- reviewing lists
- scanning waypoints (those on the planned route and in the event of aircraft going direct), and
- looking for wrong-way altitudes.

Controllers apply a deeper knowledge when considering some of these factors. For instance, turning an aircraft or giving it a direct routing could create a wrong way altitude, while giving a very long direct routing can cause problems for flight plan data processing. As a whole, this scanning is critical to understanding the airspace and traffic flows, and this understanding informs scanning.

5. STAYING IN CONTROL MEANS UNDERSTANDING THE AIRSPACE AND THE PREDOMINANT TRAFFIC FLOWS

Controllers are trained to have a strong mental model of the airspace, geographical layout, boundaries and predominant flows. Over time, controllers develop sets of scenarios and strategies. With a solid mental model for the airspace, the strategy for managing air traffic demands relies on monitoring and responding to system prompts and maintaining an active scan, as described above. Related to point 2 above, controllers also need to know the limitations of surveillance and communication coverage, on the part of both the ATM system and the aircraft equipage, as this determines the separation standards to be used.

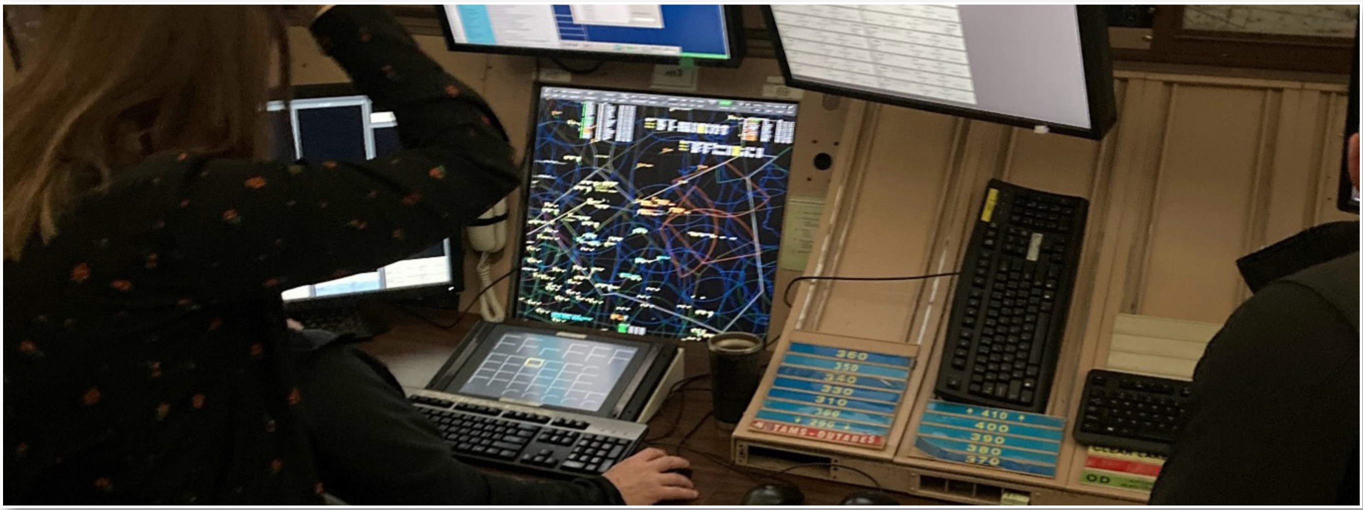

Figure 3: Current En Route Working Position (note: the controller is demonstrating functionality; the display would not normally show these arcs)

SUMMING UP

Our observations of Canadian air traffic controllers revealed an interplay between human expertise and advanced technology in managing complex airspace. Controllers effectively use automation to free up cognitive capacity, allowing them to handle more aircraft and tackle complex problem-solving tasks. The move toward more technologically advanced automated systems has transformed their roles, with increased real-time validation and confirmation of information in place of traditional planning.

Understanding and trusting the technological systems is crucial. Controllers are trained to grasp the underlying mechanisms of automation, ensuring they can interpret alerts and maintain system integrity. Continuous interaction with the display and systematic scanning practices helps controllers synthesise data into a coherent mental picture as the basis for controlling.

Despite technological advancements, fundamental skills like scanning and airspace knowledge remain vital. Based on training and experience, controllers employ scanning strategies to identify potential issues proactively and maintain situational awareness. This combined with their understanding of airspace dynamics and traffic flow enables them to anticipate and respond. Nevertheless, the specific skills of the job will change, and with each new technological advance consideration should be given to what skills no longer need to be taught or practised, and what skills may need to be reinforced.

Ultimately, these practices highlight the importance of both well-designed technological advancements and continuous training and adaptation to prepare controllers for evolving challenges and ensure the safe and efficient movement of air traffic. These findings should be incorporated into the next generation of ATM systems.

As NAV CANADA looks to the iTEC (interoperability through European collaboration) collaboration for its future ATM system, these insights will help us shape our journey to trajectory-based operations, as well as initial and refresher training, ensuring people remain in control, supported by technology.

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Anders Ellerstrand

DEALING WITH GAPS IN THE LOOP

Despite advances in technology, human intervention often prevents accidents and more generally ensures that things work, filling in the gaps. Rather than eliminating people from the loop, improving human performance is essential, argues Anders Ellerstrand.

KEY POINTS

- **Systems aren't perfect:** Safety-critical systems may be very well designed, but they are not perfect.
- **Human intervention mitigates system flaws:** Good system performance is not achieved despite the human problems, but because of our ability to mitigate flaws that exist even in a very well-designed system.
- **Automation cannot replace human adaptability:** Humans possess the creativity, experience, and flexibility to manage complex, unpredictable scenarios that automation struggles to handle, such as severe weather deviations or system malfunctions. Humans can navigate competing goals, adapting their decisions based on the context.
- **Human performance is essential to safety:** Rather than removing humans from the loop in safety-critical systems, efforts should focus on enhancing human performance and maintaining the human contribution to system safety.

Most people would agree that the global aviation system is an example of a very advanced and complex system, with an excellent

Most people would agree that the global aviation system is an example of a very advanced and complex system, with an excellent safety record.. The recent ICAO Fourteenth Air Navigation Conference reported that "the global accident rate decreased to 1.87 accidents per million departures in 2023, down from 2.05 in 2022." So, we have a mature and well-performing aviation system. But it's not perfect. The imperfections tend to be put down to the human contribution, and the concept of having the human in the loop is increasingly questioned.

We know there are problems with us, the human parts. We have limitations. We make errors. There is unwanted variation in our performance. And we are somewhat unpredictable. And, on top of that, we are expensive, while everyone is trying hard to reduce costs in a competitive world. It might seem to make sense to replace humans, or gradually take them out of the loop, only performing the things we cannot yet automate, and not making too many decisions.

This option often comes up whether we are talking about safety, efficiency or capacity. However, I think we tend to underestimate the very positive role of people in the system, to keep the system working. When designing a system, we try to imagine everything that could happen and make sure that we either have automation to handle those situations, or procedures to tell humans how to do it. But there are lots of everyday and long-term problems with these technologies and procedures. And sometimes, situations occur that no one imagined. As a result, there is simply no effective automation or procedure describing how to manage the situation. We tend to forget the role of the human in mitigating these problems. I will try to give you an idea of what I mean via a few examples from experience.

"We tend to underestimate the very positive role of people in the system, to keep the system working."

MITIGATING RADAR FAILURE

An ATC centre once experienced radar failure. There were no alarms and no obvious reason for the failure. The problem disappeared after some time. Afterwards, the investigation concluded that intensive solar storm activity at the time of sunrise was the cause. No-one expected that to be possible. But humans were in the loop, both technicians and ATCOs, and humans don´t stop working just because they lack instructions. Noticing that not all radar systems were affected in the same way, it was possible to adapt and improvise to look for ways to handle the problem. It was a serious incident, but thanks to the humans in the loop, there was no real risk of an accident.

"Humans don´t stop working just because they lack instructions."

SEVERE WEATHER MANAGEMENT

Sometimes we know about things that could or probably will happen, but procedures are still inadequate. One example that I have been looking into is handling a severe weather situation. This typically includes aircraft changing their route to avoid thunderclouds. A system to manage traffic flows based on horizontally separated routes could become useless as aircraft start to leave their routes to avoid thunderclouds. As part of this work, I interviewed pilots and ATCO colleagues, who told me that severe weather management is covered poorly in both pilot and ATCO training curricula, and that standard operating procedures are often limited. For example, the ICAO standard phraseology does not provide much support. I worked as an ATCO for 40 years and can´t remember any formal training or procedures aimed at handling weather avoidance.

But lacking instructions does not mean that the human stops handling the situation. Experienced colleagues' knowledge is transmitted to less experienced colleagues, even if it is not in the curriculum. Creativity and adaptation provide workable methods in challenging solutions. Some of my interviewees were actually hesitant about the idea of introducing standards. One reason is that two situations are never the same, and a lack of procedures can give the necessary room for flexible adaptation.

Imagine designing an automated system that is going to handle a complex thundercloud situation, with traffic deviating in large parts of the airspace, without the human in the loop.

DEALING WITH DRONES AND OTHER RAPID DEVELOPMENTS

The world is constantly changing but the design of methods to handle new problems tends to lag behind. One obvious example concerns drones. We are told that drones are technically capable of lots of new things, but there is a lack of regulations, procedures and training. In my old job as a Watch Supervisor in an ATC centre, I remember when we started getting phone calls from drone operators seeking permission to fly in restricted airspace. Initially, we were not prepared for this. Temporary solutions had to be invented quickly – like a blank piece of paper to document the permissions we gave. Thereafter, procedures and methods were designed. Similar things happen all the time. For instance, aircraft were suddenly able to fly offset, but ATCOs had not yet received training or even information about it. Still, the situation was handled, because we have the human in the loop.

PREVENTING AND RECOVERING FROM SYSTEM CRASHES

I remember in my early days as a Watch Supervisor. One part of our then very modern ATM system occasionally 'crashed'. No-one knew exactly why, but our technical staff found out that if we did a proactive reboot of that system once a week, we could avoid the crashes. Eventually, a more durable and permanent solution was found.

I also remember a time when all controllers were told, in an ad hoc written procedure, not to use a certain tool in the system. The reason was that using that tool in a certain context could cause the whole system to crash. With humans in the loop, it is possible to adjust the system very quickly to avoid the unwanted effects of design errors and other 'gaps in the loop'.

ONLY PEOPLE CAN HANDLE GAPS IN THE SYSTEM

Technical systems tend to be very good at doing what they are told to do, in a predictable way. But many situations cannot be foreseen, and solutions cannot be programmed or prescribed, so our human ability to adapt is very valuable. With my examples, I am claiming that our systems are far from being good enough to be managed without the human contribution.

> "When humans confront a new, unforeseen situation, we are often creative enough to invent a way to solve it."

Having the human in the loop is very often the best risk mitigation we have. Of course, recruitment and selection must be done properly. And people need to be provided with quality training and continuous information, and have sufficient experience. But given this, when humans confront a new, unforeseen situation, we are often creative enough to invent a way to solve it. Every day, perhaps every second, humans are filling the gaps in the system. And most of the time, we see that as a normal part of what we do; nothing extraordinary, and nothing requiring a report. But as a result, we lack the statistics to demonstrate that most system flaws are mitigated by the human in the loop. So we must make more time to recognise and understand the human contribution, and better support the humans in the loop so that people stay in control.

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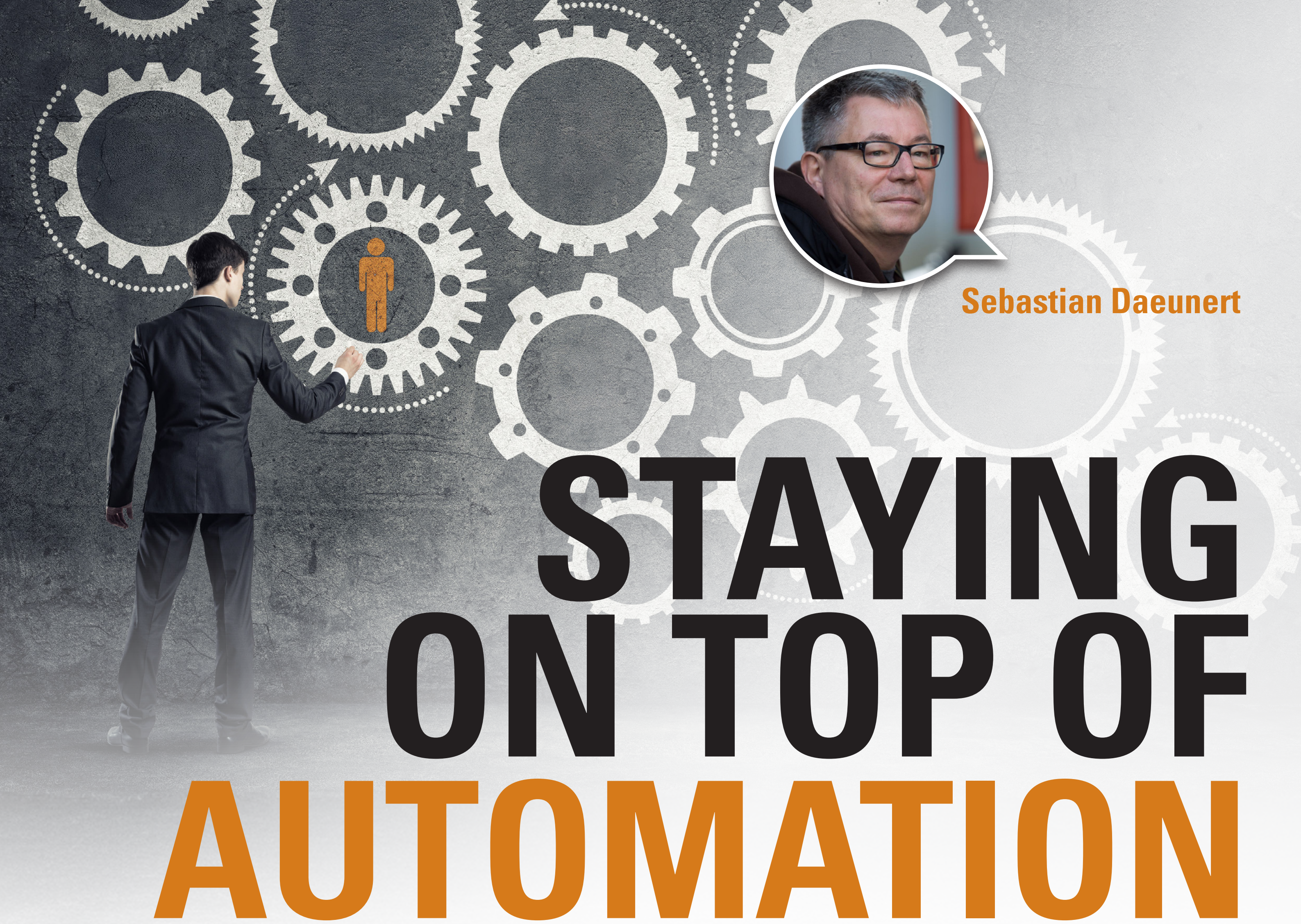

Sebastian Daeunert

STAYING ON TOP OF AUTOMATION

In an era of rapid technological change, maintaining control over automated systems is increasingly complex. Sebastian Daeunert explores the impact of 'little assistants' and the challenges we face in staying in control, from manual skills to learning from reporting. Are we in control of technical systems, or are they in control of us?

KEY POINTS

- **Rapid technological advancements:** Automation and artificial intelligence are rapidly transforming our world, especially within high-risk organisations, introducing new challenges in maintaining control and understanding technical systems.
- **Operator dilemmas:** Operators often face dilemmas when automated systems provide recommendations that could lead to bad outcomes, balancing following automation and relying on training and experience.
- **The role of reporting:** Continuous reporting of system issues by operators is crucial, even if they are unsure of the nature of the problems. Management must encourage reporting and act on these reports to improve system reliability.
- **Reversion to manual:** Practising operations without automated assistance is essential to ensure that users can effectively switch to manual control when necessary and to understand the overall system's functioning.
- **Communication and collaboration:** Effective communication and collaboration between operators, safety specialists, and management are vital to staying in control of increasingly complex systems.

It feels like times have never been as turbulent as they are these days. As I write this, new developments in automation and artificial intelligence are changing our world at lightning-fast speed. I am not referring to full automation (autonomy), but the 'little assistants' that start to invade our lives, often without us thinking too much about them. What does this mean to the operators in so-called high-risk organisations, and how do we cope? How do we stay 'on top', or in control?

Those of us who are 'old school' may remember trying to insert a coin into the public phone, vending or ticket machine. It would sometimes fall through, coming back out via a little compartment at the bottom of the machine. We tried again and again, eventually rubbing it on the machine next to the slot, the place where the scratches showed we were not the first to do that and certainly not the last. Suddenly – voila! – the machine accepted it. By rubbing the coin against the machine, we believed we had beaten the machine, as it finally recognised our payment. Did we just experience a miracle of static electricity? No. Vending machines work mechanically so scraping the coin doesn't have any effect other than inserting the coin in a slightly different way, which statistically increases to chances of success. However, we erroneously attributed the success to 'getting rid of the static electricity'. This is a fine example of a placebo effect: a positive result is attributed to a fake intervention.

"I wonder whether we are deceived in our complex working environments, believing we are actually in control of systems, or even understand them."

From this small example, I wonder whether we are deceived in our complex working environments, believing we are actually in control of systems, or even understand them. Let us take a look into an imaginary radar system at an imaginary centre operated by an imaginary ATC provider. I am deliberately not using names as I am inventing this scenario. It could be an area control centre, railway operational facility, or intensive care unit – anywhere where automation plays a major part in our work.

Let us imagine a new software, not very different from what we are used to, but with additional functions and some small changes. Software developers have programmed it, operators have given their input, it has been tested (of course in sandbox mode, disconnected from reality so it could do no harm) and assessed as being safe. Additionally, people have been thoroughly trained on how to use it. In other words, everything should be working fine. And it does!

So, we are all set. Apart from the usual bout of complaints by operators ('those who always complain about everything'), it all works. Most people are happy.

Then suddenly, after having worked flawlessly for months, the system recommends an action to the operator that could lead to disaster.

What will the operator do? He or she may follow the recommendation and if things go wrong, will have to face the *"Why did you not recognise this?"* question, followed by: *"Why did you follow the automation, we trained you at great expense to be a competent person. You should have known from experience!"*

Alternatively, the person may decide not to follow the recommendation and, based on their experience do what they were trained for. If the outcome is positive, the person may receive a *"Great job!"* and a pat on the shoulder. But if the outcome is negative the question likely will be: *"Why did you not follow the automation? That's what we installed it for!"*

This places the operator in a dilemma. Before the outcome is known, neither path is clear. So which path to choose?

For those who grow up with new systems, never having experienced previous ways of working, these possibilities might be limited even further. Even though their gut feeling says that something is not right, they may not have experienced or have been trained in possible alternatives. And so, they do not know what to do.

CONSIDER THE FOLLOWING ADDITIONAL SCENARIOS:

- An error in the system has been known for many months. The operators developed a workaround that worked fine, but they never reported it.
- An error in the system has been known for many months, but since it occurred so rarely, was untraceable, and could not be reproduced, it was impossible to fix.
- An error in the system has been known for months and has been reported many times. Eventually operators give up, thinking their reports are not taken seriously and stop reporting, which leads those supposed to fix it into believing that the error is no longer present.
- An error has been fixed but the fix leads to new errors in the system or slight changes in how to operate the system, which are not explained, as it is only a small update.

These are some of the practical dilemmas of 'staying in the loop' for 'people in control'.

So, what can we do about this? When it comes to automation support, it is important to practise our work without using the available new automation aids on a regular basis so we still have competence in performing our work when those 'little helpers' fail, or do things that are not as they should be done. We can only identify false inputs by automation if we know the original system. This way, when things go wrong we are still able to switch to 'Plan B'.

"It is important to practise our work without using the available new automation aids on a regular basis."

If we have never worked without automation, or only on a very rare basis, we might lose our competence to *"save the day"* when it fails. This manual practice can help to understand 'the big picture' so that we do not limit our vision to our small piece of the puzzle. This is not easy as cost reduction pressures tend to erode training opportunities.

When it comes to reporting, it is important for operators, safety specialists, and management that operators continue to report things they find awkward or difficult, even if they are not sure that these are errors inside the system. This must be encouraged, even if reporting brings frustration and workload for all. Many factors can discourage reporting, and so a constant effort is needed to keep in mind why it is so important to keep up the motivation to report, understand the issues, and act on them.

Those in non-operational roles may face problems from a different perspective and rely on the information that operators give them. For those who oversee the business, it is important to listen and take things seriously. Keep in contact with those at the 'sharp end' and actively seek to exchange information. Take reports seriously but relay your thoughts, measures and reactions regularly to those who made the reports. They need the feedback, even if it is a *"negative"* or *"it takes time, but we are on it"*.

Do not leave operators in the dark. Without a fundamental understanding of how things work, and why things go wrong, we tend to make assumptions, as with the coin-operated machine. And if, as a technical specialist, you notice something amiss yourself but are unsure whether to report it or not, speak to the operators and get their views. Taking each other seriously, working together between disciplines and teams, and looking beyond our own parts of the system helps us all to stay 'on top', and more in control of what we do.

"Do not leave operators in the dark. Without a fundamental understanding of how things work, and why things go wrong, we tend to make assumptions."

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Sébastien Follet Salvador Lasa Ludovic Mieusset

WELCOME TO MY LOOP

In aviation, as in other sectors, every professional operates within their own 'loop', believing they are in control of their work, and sometimes others' work. However, disconnected loops can lead to a breakdown in communication and understanding. Sébastien Follet, Salvador Lasa and Ludovic Mieusset explore the 'Tower of Babel' problem and offer a remedy that we can all work towards.

KEY POINTS

- **The feeling of being in control:** Each aviation professional feels that he or she is 'in control', and believes that they know how work should be done.
- **The problem of isolated 'loops':** Isolated 'loops' and different languages within aviation professions can lead to miscommunication, misunderstandings, and disconnections between how work is actually performed (work-as-done) and how it is supposed to be done (work-as-prescribed).
- **Shared understanding:** Building a shared understanding of each other's roles and responsibilities can help prevent 'Tower of Babel' scenarios and ensure people work towards common goals.
- **Exploring multiple perspectives:** Aviation professionals should be encouraged to step outside their own roles and explore the perspectives and challenges of other groups.
- **Informal interactions:** Encouraging informal interactions, such as casual conversations and social events, can improve relationships and help bridge gaps between different professional groups.

Developments in modern aviation have followed a path defined by the aspirations of many kinds of professionals aiming to be the 'people in control'. Phraseology is one example. For air traffic controllers (ATCOs), phraseology is perhaps the most important tool. It helps them to fulfil their mission, as its versatility provides different solutions for a wide range of scenarios. Multiple safety issues and regional disparities have steered its evolution locally. But one regulator decided to regain control, returning to a more standardised phraseology. Frontline operators – and especially air traffic controllers or ATCOs – perceived this as a step backwards. For them, the amendments failed to integrate lessons learned from experience and deprived them of a tool that allows them to be operationally 'in control'. So, who are the people in control, and what do they think they control?

WHO IS IN CONTROL?

ATCOs, pilots, front-line managers, middle managers, senior managers, national aviation authorities, EASA, ICAO… Each feels that they are in control, and each believes that they know how work should be done. As ATCOs, we are in control of what 'provision of a control service' means to us. We are in control of what we are trained and prepared to do, and what to accept as working conditions.

Managers also have their own vision of being in control. To stay in the loop and control the work, managers sometimes produce new rules and procedures. Managers also stay in control by examining what is done and scrutinising

> "It is hard to cope with the constant waves of procedural changes and add-ons. Huge effort is required just to keep yourself up to date."

unwanted events. They try to stay in control by ensuring that work-as-prescribed corresponds with work-as-done. In general, managers may feel that they are 'in control' of safety, by pushing 'normative safety', especially by complying with safety performance standards – how things 'should' be done.

This creates a challenge for front-line operators like ATCOs: it is hard to cope with the constant waves of procedural changes and add-ons. Huge effort is required just to keep yourself up to date. Many procedural changes are perceived as 'patches', unfit to resolve identified problems. When an issue requires strong, long-term solutions, and the change doesn´t match expectations, distrust can arise.

So ATCOs, as people in control, tend to adopt 'survival' positions by sorting out what is really needed amid the constellation of procedures and rules. Work-as-done progressively overtakes work-as-prescribed. This defines what is 'in the loop' and ultimately their professional identity.

THE TOWER OF BABEL

The Tower of Babel is a parable from the Bible that is meant to explain the origin of the worlds' languages and the spread of humanity across the world. The origin myth states there was once one common language, but that God chose to confuse the language and scatter languages, so that people could no longer understand one another.

Part of our problem is reminiscent of the Tower of Babel. Every group speaks their own language, adapted to their context. Some language differences even highlight misunderstandings between ATCOs and local safety departments. How can an ATCO accept the term 'abnormal convergence' for the vectoring of two aircraft when all separations have been guaranteed? And what about the label of 'near-CFIT' (near controlled flight into terrain) for a plane that has the ground in sight?

"Part of our problem is reminiscent of the Tower of Babel. Every group speaks their own language, adapted to their context."

Different languages and meanings can transform the aviation system into a Tower of Babel. Each profession tends to stay within its group, forming a fairly closed loop, connected with neighbouring professions through bridges (see Figure 1). These bridges should help each loop to maintain awareness and understanding about other loops. But distrust means that managers do not get accurate and complete information about work-as-done, leaving them with gaps and inaccuracies in their understanding of how people work (work-as-imagined). One reason for this is self-preservation attitudes, which lead operators to talk or write about what they are supposed to do (work-as-disclosed) according to procedures (work-as-prescribed), instead of what they actually do (work-as-done). How can managers stay in the loop of operational staff when they rely on what operators – fearing punitive consequences – are prepared to say (see Shorrock, 2023)?

Figure 1: The 'closed-loops' Tower of Babel in the air traffic control system

In this Tower of Babel scenario, gaps of different sizes between groups are linked from point to point by bridges, which are more or less robust. Gaps spanned by weak bridges often result in misunderstandings and suspicion between operational groups responsible for work-as-done and non-operational groups responsible for work-as-prescribed.

Poor or deficient communication can lead to implementation of inadequate measures. Suspicious and full of distrust, each closed-loop group (ATCOs, pilots, managers at different levels, regulators...) tends to develop its own ways to self-generate the feeling of control they need. But there is a difference between a subjective sense of control and actual control. So how do we resolve this? Consider the following example.

EXAMPLE OF DECISION-MAKING PROCESSES IN A MULTIPLE-LOOP ENVIRONMENT: WHEN PRESSURES SEAL THE LOOP

In a context of continuous growth in traffic figures, a large regional airport is expecting a sudden increase in capacity demand. This pushes management authorities to act and find solutions to cope. Eager to achieve fast results, an infrastructure expansion project is swiftly laid out. Needs are identified, objectives defined, and the path to be followed and the means required for the journey are determined. Airport management has defined its own loop and feels in control of this loop.

At the same time, the rest of the players involved (ANSPs, ATC, contractors, regulators, supervision agencies, and all workers in each of them…), start to bring their own needs, objectives, concerns, and measures to mitigate associated risks. Each defines their own loop. Now, the stability of the airport management's loop is under threat from other loops. Interactions between loops challenge the airport management's feeling of being in control. And actors' concerns are sometimes too different, resulting in difficulties to understand each other. Why are ATCOs so concerned about training and safety issues when it's going to be the same scenario with some 'not-so-big changes'?

The project progresses and work is done as planned. However, close to the end of the project, airport management realises that the intervention won't completely fulfil the desired objective: increase airport capacity. They failed to understand other loops' language and incorrectly assessed their needs. Time is ticking and pressure growing. Corrective actions are required. Airport management decide to carry out additional work using spare funds. Manoeuvring area adjustments on the airport are made to improve the traffic flow, responding to the ANSP loop's criteria.

Unfortunately, the high peak season begins, and these new infrastructures cannot be used as they don't match the regulator's perspective: such modifications were not included in the initial blueprint. Airport managers and aviation oversight authorities, sealed in their respective loops, missed the complimentary work needed for such changes.

CONNECTING THE LOOPS

The key to transform the Tower of Babel scenario into a system of interconnected loops aiming towards common goals is improved communication among all stakeholders. This requires a minimum of core knowledge for every stakeholder. This is present in some loops (especially operational roles), but not others. The definition of recommended minimum core knowledge for managers may help to reduce barriers between top authorities' loops and other players' loops.

A path to a virtuous spiral involving all stakeholders also relies on creating conditions for everyone to explore others' loops. Pilots, ATCOs, engineers, etc., tend to use informal contacts as a way to develop mutual understanding and smoothen operations. This informal rapport among colleagues can save the day: it happened when a tower supervisor, despite a note describing maintenance works to be done in a few nights, spent time chatting in a corridor about the potential impacts on operations. It turned out that the technical service wrongly believed that the tower was going to be closed (a large part of the floor had to be removed). Everyone, sealed in his or her own loop, failed to notice this important issue. Enhancing interactions can greatly improve information flow in all desired directions: every stakeholder must explore other loops to understand and improve how things work.

The aviation community should take advantage of the benefits of ad hoc social interactions and promote them throughout the whole system of stakeholders. Informal and inclusive social events might be a way to bring people together. Another way is to create the opportunity to better understand each other's work. For instance, a local control service could organise an open day for airport stakeholders. By improving informal relations and continually exploring each other's activity, everyone has the possibility to understand each other's language, reducing the Tower of Babel problem. It is time for us all to open our doors with one motto in mind: "Welcome to my loop!"

"By improving informal relations and continually exploring each other's activity, everyone has the possibility to understand each other's language, reducing the Tower of Babel problem."

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COLLABORATION WITH AUTOMATION

OVER THE LOOP, INSIDE THE LOOP OR OUTSIDE THE LOOP?

With the current hype for artificial intelligence, aviation and other sectors are looking at how new technologies can be exploited to benefit performance. But AI brings – and expands – problems already known about from research in automation. Fabrice Drogoul and Philippe Palanque explain why caution is required.

KEY POINTS

- **AI in air traffic management:** New AI tools are being proposed for air traffic management. These technologies can either replace or assist human tasks, but they bring fresh challenges, especially in roles where safety is critical. In safety-critical contexts, very high reliability is required. This is not yet achieved by AI.
- **Human-AI teamwork:** Roles can vary in human-automation setups. In some cases, the human is fully in charge with automation as a tool. In others, control is split or even reversed, where the system takes the lead. It's crucial to get the balance right to keep humans "in the loop" where it counts.
- **Complexity and risk:** Complexity brings increasing risk of system failure, and so aviation regulators are cautious, advising against quickly rolling out new AI technologies until they've proven reliable.
- **Regulatory limits:** Only certain types of automation where humans can stay in control will be approved in the near future. While full AI autonomy is a possibility, deployment, robustness, and safety issues will prevent early use of AI technologies in safety-critical contexts.

INTRODUCTION

The recent advances in artificial intelligence (AI) technologies have been perceived as a game changer in air traffic management as in many other areas. Statistical AI technologies that are used for tasks such as pattern recognition or item classification are based on machine learning (ML) technologies. Symbolic AI technologies that are used for tasks such as diagnosis or decision-making are based on rule-based technologies. These technologies are very different, but they share the fact that they are designed to replace or augment human-performed activities with computer-performed activities. Whether or not AI technologies are embedded, this process has been known for nearly a century as 'automation', and many limitations, pitfalls and drawbacks have been studied (see Drogoul & Palanque 2019). These are usually exacerbated when AI technologies come into play.

A concrete example of ML-based computer vision technologies is the one being deployed for detecting undesired objects on airports` runways (see Noroozi et al., 2023). In that contribution, the authors propose a stepwise processing of computer images for foreign object detection (FOD). Based on a widely used training dataset called YOLOv4, the highest accuracy is about 93.81%. This could be seen as a good level of precision for the AI technology. However, this means that the system is wrong once every 16 FOD. In numbers, the system produced 134 false positive (a non-existing object was detected) and 215 false negatives (a non-detected object was actually present on the runway) and 1566 true positives. With respect to the expected reliability level of safety-critical systems, this reliability level would be considered poor.

The following generation of work considered automation with electronics and algorithms. Already in 1985, Chambers and Nagel were worried about automation drawbacks "As more and more automation is incorporated in aircraft, the essential question becomes one of autonomy: Should the automated system serve as the human pilot's assistant, or vice versa?" (p. 1187).

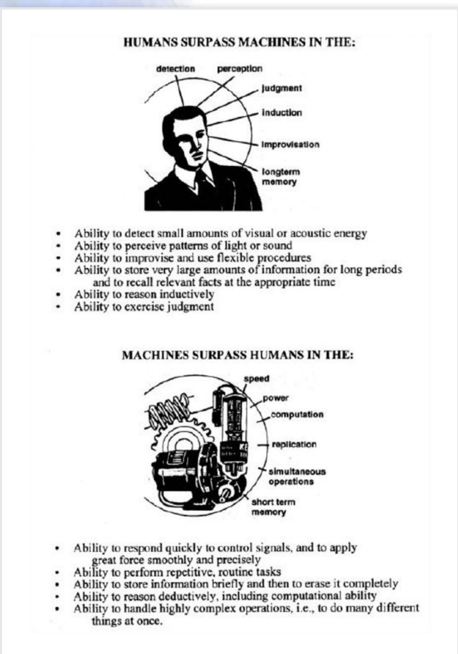

Figure 1: A reproduction of Figure 1 from (Fitts, 1951) showing the reference to mechanical automation

Advances in AI technologies are expanding the potential for automation, enabling computers to take over tasks that are difficult to describe with algorithms, such as generating images from textual prompts. A recurring key element in the process of automatisation is that humans remain involved and must collaborate with the automation to carry out their tasks.

DIVERSE VIEWS ON HUMAN-AUTOMATION COLLABORATION

The ways in which humans can collaborate with automation is presented using the GUSPATO model in Figure 1. GUSPATO is the acronym composed with the first letter of the seven types of collaboration where control, authority and responsibility (according to the terminology of the RCRAFT framework for automation of Bouzekri et al., 2021) migrate between the technical system embedding automation and the human.

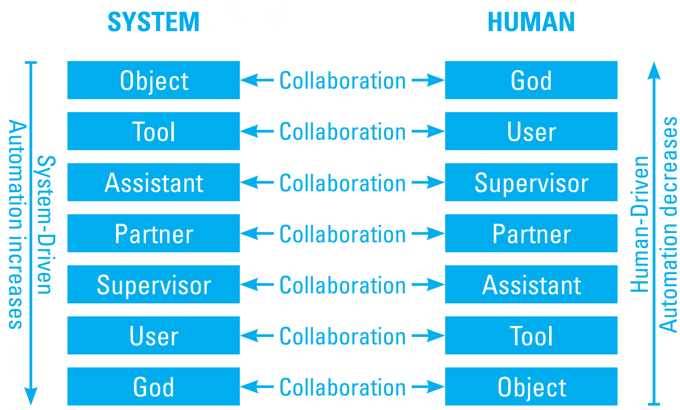

Figure 2: GUSPATO: A seven-level classification of human-system collaboration

Each line of the figure corresponds to one type of collaboration with automation. The first line describes a collaboration where the human is seen as a 'god' and creates the system and its outcome. In that case the system can be seen as an object belonging to the creator.

The second line represents the classical use of computers where the system is seen as a tool used by the user or operator. The tool may embed some automation but the control, the authority and the responsibility remain with the user/operator. The human is, here, inside the interaction loop perceiving information provided by the system, cognitively processing it and triggering system functions when appropriate.

Line three shows an unbalanced sharing of control, authority and responsibility between the system (as assistant) and the human (as supervisor). Automation is more complex, and more complex tasks are performed by the system, following a delegation of tasks by the human. The human still holds control, authority and responsibility but positioned over the interaction loop (monitoring the partly autonomous behaviour of the system).

Line four in the middle of the figure corresponds to a symmetric relationship for control, authority and responsibility between the system and the human. In this type of collaboration, both entities can delegate tasks to the other entity and monitor their performance. Authority and responsibility are shared, and the human can be considered as outside of the interaction loop when the systems perform tasks autonomously.

Line five corresponds to reversal of the collaboration presented in line three but now the human is an assistant to the system. In that context the system might require the human to perform tasks and will monitor the performance of the human. Such reversal of roles in the collaboration is similar for the last two lines of the figure. The last line corresponds, for instance, to generative AI where objects are created by the system and the human is an object amongst many others.

ROBUST AUTOMATION IN SAFETY-CRITICAL CONTEXTS

A key issue in the use of GUSPATO model is that the lower lines require more complex algorithms and, in some cases, might require the exploitation of AI technologies. While this might be acceptable for entertainment or mass-market systems, complexity in computer systems is a precursor for failures (at least in the area of software where "Complexity metrics are better predictors than simple size metrics of fault and failure-prone modules", according to Fenton and Olhsson, 2000).

When new technologies for producing computing systems appear (a new programming language, for instance) significant effort is required to harden the technology making it suitable for deployment in critical contexts. This is why it is wiser and safer to keep older technology in use and to refrain from being an early adopter in order to avoid disillusion, as is the case with the fantasy of fully autonomous driving (Cusumano, 2020).

Level 1 AI: assistance to human

- **Level 1A:** Human augmentation
- **Level 1B:** Human cognitive assistance in decision-making and action selection

Level 1 AI: human-AI teaming

- **Level 2A:** Human and AI-based system cooperation
- **Level 2B:** Human and AI-based system collaboration

Level 3 AI: advanced automation

- **Level 3A:** The AI-Based system performs decisions and actions that are overridable by the human
- **Level 3B:** The AI-based system performs non-overridable decisions and actions (e.g. to support safety upon loss of human oversight)

Figure 3: The levels of automation based on Human-AI interaction in the EASA AI Roadmap

> "In the aviation domain, regulators such as EASA are defining safeguards to prevent the exploitation of AI technologies before there has been a demonstration that they have been made robust enough."

In the aviation domain, regulators such as EASA are defining safeguards to prevent the exploitation of AI technologies before there has been a demonstration that they have been made robust enough to meet the development assurance and safety levels identified for the target system. The EASA roadmap to AI (in its current version 2.0, EASA, 2023) provides a clear path toward adoption of AI in the long term, demonstrating that only the first three lines of GUSPATO model will be available in the coming years. For Human-AI teaming, EASA has now provided a clear distinction between a) cooperation where AI and humans are working together but with distinct goals and collaboration, and b) where AI and humans are working together towards the same goal (see Figure 2). The advanced automation level foreseen in the long term encompasses some full automation that can be overridden by the operator (human still in control). Only as a safety tool (when incapacitated) can AI perform in the most advanced automation level actions and take decisions that cannot be overridden (see Figure 3). This corresponds to the fact that AI trustworthiness requirements, as identified in EASA (2020), are not met yet.

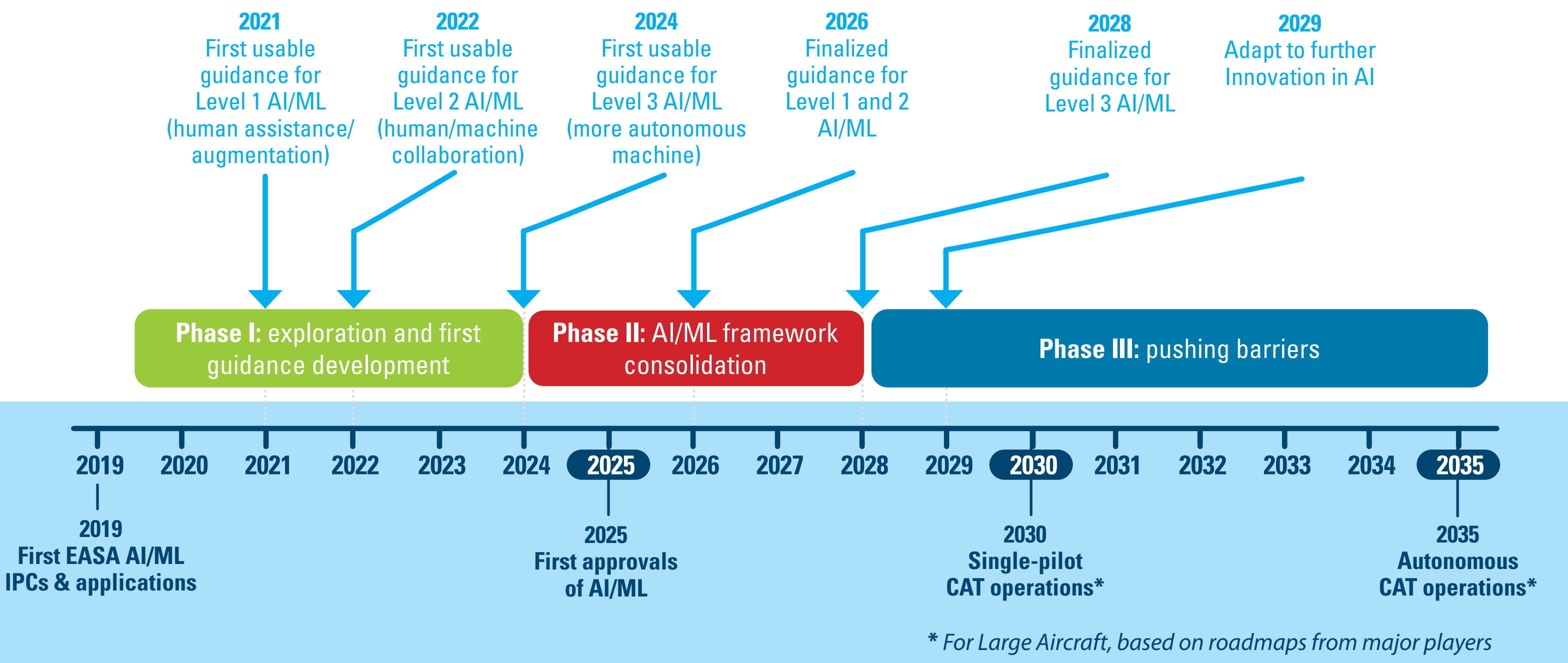

Figure 4: EASA AI Roadmap target dates for deliverables (adapted from EASA [2020], p. 13)

This paper presented the issues related to artificial intelligence technologies, and in particular machine learning, in the context of automation. The trustworthiness of these technologies is far behind the currently deployed safety-critical technologies. Based on output from the EASA AI task force, we can see that certification authorities take trustworthiness issues very seriously, and understand that deployment of AI technologies is not there yet. We are thus far away from a real collaboration between such technologies and operators, at least in such critical contexts. A lot of research work remains to be done in order to go from design options to implementation, certification and deployment of such systems.

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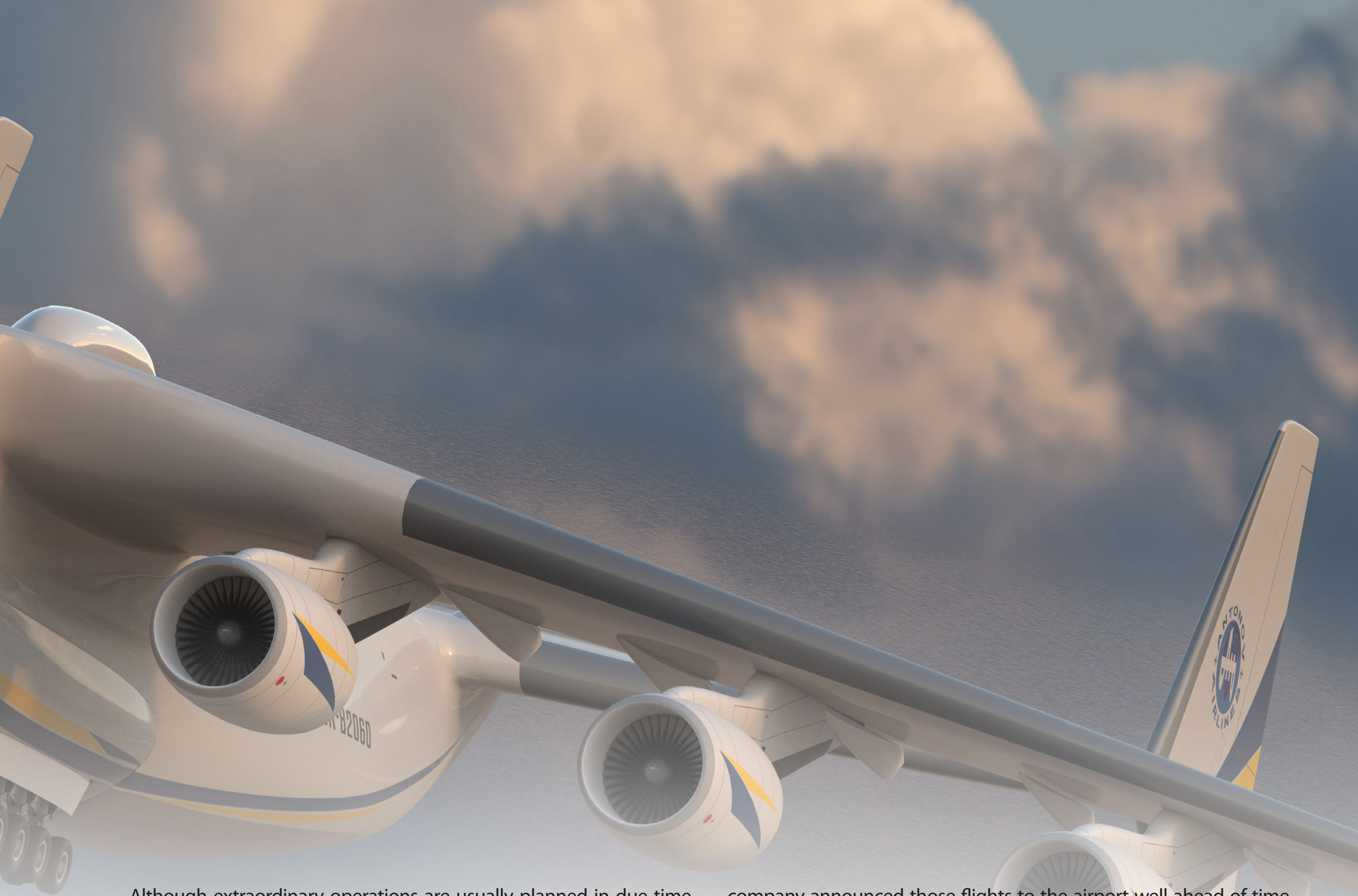
THE COSSACK FROM THE CLOUDS

Ulf Henke

Staying in control on the ground involves a blend of planning and adaptation, but the quality of our relationship is fundamental, and often taken for granted. As Ulf Henke recounts, a seemingly routine night shift took a dramatic turn with the arrival of a colossal aircraft. What ensued was a testament to competence and collaboration across teams.

KEY POINTS

- **Relationships with colleagues:** Building strong relationships with colleagues across your organisation and with external partners provides familiarity to allow for smoother communication and faster response during unexpected events.
- **The role of expertise:** When procedures aren't available, it is necessary to rely on expertise and the combined knowledge of the team in order to adapt and improvise to find solutions.
- **Clear communication:** Clear, concise and precise communication is essential for coordinating efforts and ensuring shared understanding of the situation, especially during critical events.
- **Culture of collaboration:** While you can't predict every situation, having a culture of collaboration and open communication allows us to handle unplanned events effectively as a team.



Although extraordinary operations are usually planned in due time, every now and then unexpected events happen. A good example of how to cope with such an unplanned event happened several decades ago. The event highlights the importance of relationships for communication, collaboration, and networking in order to stay in the loop. It shows how, during a critical situation or extraordinary event, complex adaptations may be needed, which rely on human expertise and interactions in the moment. The passage of time in this case does not affect the lesson from the story.

The context was different at that time: the standards and recommended practices (SARPs) published in ICAO Annex 14, the infrastructure of our airport, the aircraft involved, the political situation, and other conditions. However, the way the event was handled by our experienced supervisor showed excellent professionalism, including very good communication skills. It also showed the importance of networking within the organisation and external partners.

By that time our airport was approved by the competent authority for all aircraft below a certain aircraft classification number/pavement classification number (ACN/PCN). According to ICAO Annex 14, the most demanding aircraft in regard of wheelbase or wingspan was the Code E aircraft. Larger aircraft were not known to ICAO. (In fact, at that time there were only three aircraft more challenging than the Code E, and one of them – the C5 – was a regular guest on the military apron of the airport.)

Several months prior the event, there was a massive earthquake in the former Soviet Union. Multiple international disaster relief flights were transiting the airport regularly. Often the AN-124 was used to transfer different kinds of support equipment. But when it did, the company announced those flights to the airport well ahead of time. This enabled airport engineers to calculate possible routings, stands and other operational information prior to the expected arrival of the aircraft.

Early in my career as an apron controller, I was nearing the end of a quiet night shift. It was still dark outside, a little foggy and we were slowly preparing for the first inbound rush. That was when a short call from the tower via intercom changed the shift completely.

"Apron from Tower, look to the east, presently on four miles final and shortly appearing out of the fog, we have a rather large aircraft diverting to our airport. The cockpit crew has declared a state of low fuel, but it´s not an emergency. It just wants to refuel and then continue to its original destination."

"Tower, copied. We are used to larger aircraft. Is it a C5 for the airbase? In this case you must inform the Air Force."

"Wrong guess, apron. It´s a little bit larger."

"Oh, we had AN-124 here before. No problem."

"Apron, even a little bit larger. The flying crew doesn´t speak English too well, but they have an American interpreter on board."

It turned out that it was the Antonov AN-225 Mriya (NATO reporting name: 'Cossack') – a strategic airlift cargo aircraft with six engines mounted under the wings and a maximum take-off weight of 640 tonnes. It was the heaviest aircraft ever built with the largest wingspan of any operational aircraft at 88.4 m. Only one aircraft was ever completed and put into active service. The AN-225 was on a disaster relief mission from the United States to Moscow. Due to unfavourable winds, the aircraft was not able to fly non-stop as planned, and needed an additional fuel stop in Western Europe. No one expected this aircraft without prior notice.

The majestic bird appeared out of the fog. While the controllers on their working positions observed its approach, the supervisor was already on the phone to the Air Force base on where to refuel, since on the civilian side there were no stands available for an aircraft this size. Additionally, all available information on the An-225, as well as on the infrastructure of the airport, had to be gathered for safe guidance after landing.

And still more coordination had to be performed: fire protection had to be provided, the source of fuel had to be clarified, a route proposal from the runway to a refuelling position had to be evaluated, the vehicles and the personnel had to be transferred to the meeting point, and so on.

The aircraft landed, vacated the runway clear of the sensitive and critical areas, and then the flight crew awaited further instructions.

When most of the coordination in the apron control tower had been completed, the supervisor decided to leave his desk and drove to the aircraft together with all available marshallers. The supervisor then supervised the obstacle clearance of the aircraft, with one marshaller directing the aircraft and two others monitoring the wing and engine clearances, also checking for possible blast issues. At certain parts of the taxiway, the aircraft had to be guided off the yellow guidance line to ensure sufficient clearance to nearby obstacles.

Until then, it remained uncertain whether the aircraft could be towed, as it was unclear whether a suitable tow bar and truck were available. The guiding crew had only one chance on the routing. When the aircraft was clear of the manoeuvring area, it was decided not to enter the military apron because of the limited clearances. Instead, the handling and refuelling of the aircraft was performed on the inner taxiway.

The inner taxiway just north of the airbase was closed for aircraft movements. Refuelling trucks and other handling personnel were guided by marshallers onto the taxiway in order to refuel the majestic aircraft. The airport security then was on spot to ensure that no unauthorised persons were entering the movement area to get a closer look of the aircraft. Meanwhile, the airport engineers evaluated a safe routing for departure. After a few hours, refuelling was completed and the AN-225 was guided to the departure runway with its wingtips still intact.

Years later, upon the retirement ceremony of my former supervisor, we chatted about 'the good old times' and I asked him about the event.

"Hans, tell me, what was on your mind when you found out that the aircraft would land at our airport."

He replied something like this:

"Ulf, in fact, it was very easy. First, I looked in my drawer if we had plans and procedures in case this type of aircraft would appear at the airport. However, the drawer of the supervisor desk was empty regarding this aircraft type. Then I had to find out whether the aircraft would be handled by our airport or the military. The next step was to call for a group of experts within the operational services with decision-making competence in their fields, to gain information about their staff and to identify possible hazards and mitigation measures.

"The mitigation measures were then evaluated by other experts to see what impact they would have on their tasks. The results were the basis for my decision-making. As far as to maintain obstacle clearance on the manoeuvring and the movement area, I always kept in mind that I only had one chance, since I did not know if the airplane could be towed. Thus, I was driving most of the time ahead of the aircraft ensuring that it still had a chance to taxi and depart without interfering with an obstacle. If I was not sure, the aircraft had to stop and wait until the approval on the further routing was assessed and assured."

As easy as it may sound, what the supervisor explained to me was an outstanding job under time compressed conditions. The prioritisation of the tasks and the information gathering and sharing to others were key to success. Today, the call for experts with decision-making competence to evaluate possible hazards and mitigation measures, and the communication of the results, is a basic step in an SMS risk management process. It is done prior to introducing new procedures or major changes in infrastructure. But this event happened decades before a formal SMS was introduced in aviation, and for an unplanned event involving a unique aircraft.

This event could not have been handled by automation since the problem was not identified in advance. No procedures were designed or available. But with highly competent people in control, there was a way of responding effectively, with risk assessments and mitigations enacted in situ to solve the problem in a safe and efficient way.

So, what should be learned from this event? Encourage and promote networking, not just among business suite levels but also within operational services, even when finding time is challenging. Think not only within the limit of your organisation but also within the whole operational community where you work. It is always easier to provide and gain support in daily operation from others, when they not only recognise your voice on the phone, but if they know you, your responsibilities and other relevant stakeholders face to face. Relationships are the heart of communication and culture, and can make the difference in critical situations. Relationships keep us in the loop, and help to keep people in control.

> "Encourage and promote networking, not just among business suite levels but also within operational services, even when finding time is challenging. Think not only within the limit of your organisation but also within the whole operational community where you work."

> "Relationships keep us in the loop, and help to keep people in control."

STRENGTHENING RELATIONSHIPS AT WORK: ASK YOURSELF

Who are the people and organisations that you may need to interact with during surprising events?

- How do you get to know each other formally and informally?
- What kind of communication channels might be needed?
- What opportunities may be used to create personal connections that could then be leveraged during an unexpected event?

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.

Lea Sophie Vink

Maximilian Peukert

Florian Ott

MINDS ON AUTOPILOT

NAVIGATING THE LULLS IN AVIATION

Boredom in aviation is known amongst front-line practitioners but tends to be overlooked by organisations as a safety issue. In their study, Lea Sophie Vink, Maximilian Peukert and Florian Ott explored some of the influences on boredom and how people cope.

KEY POINTS

- **Prevalence of boredom:** Boredom is a widespread issue across aviation operations, impacting pilots and air traffic controllers alike, with male operators showing a higher susceptibility.
- **Personal coping strategies:** Aviation professionals use a variety of coping strategies, offering insights into resilience amidst monotony.
- **Organisational countermeasures:** There is a concerning gap in proactive training and systematic measures to address boredom, leaving operators vulnerable to its effects, especially with increasing automation in the industry. Organisational measures are also necessary to cope with boredom.

In safety-critical sectors such as the aviation industry, aircrews, air traffic controllers and engineers have careers with many days of routine and satisfactory work. Although all staff train for unusual and novel situations and regularly practise high-pressure and high-performance events, the aviation network and safety management systems depend upon operators having a relatively quiet and monotonous job where nothing out of the ordinary goes wrong. Pilots even have a phrase for this: "Hours of boredom, punctuated by seconds of terror." But operators rarely train for this boredom, and relatively little time is devoted to education and practice about it. In the literature of Human Factors and psychology, there is surprisingly little written about how human beings cope with being bored, staying active and alert during monotonous times and – when demanded by situations – suddenly surge back to full performance and alertness.

Even more curiously, the scientific and medical academic literature is very sparse on what exactly boredom is. Is it a feeling? Is it a neurological phenomenon? What is the relationship to underloading or low arousal? Are certain people more susceptible? And how long does it take us to get bored? We are fascinated by these questions and especially the relationship to another foe of human performance: fatigue. For example, do boredom and monotony create more fatigue? Or do they reduce it because high intensity operations make us more fatigued?

With all these questions in mind, towards the end of 2023, we attempted to create a methodology to investigate the presence of boredom and monotony in aviation. Over three months, aviation professionals from around the world were invited to answer a short online survey. Primarily, the question of the prevalence and potential of boredom amongst pilots, air traffic controllers and technicians were investigated. Secondary to this was to establish what kind of coping strategies or training and systematic measures were in place. And thirdly, we wanted to test if our methodology could be replicated to delve deeper into the questions above.

The study consisted of the short boredom proneness scale by Struk and colleagues (2017) which is used to assess how prone to boredom people might be. We also utilised the Dutch boredom scale by Reijseger and Colleagues (2013) to understand if aviation had job-specific boredom issues. Finally, we utilised a series of qualitative questions about how individuals manage boredom and monotony. The first round of results did not disappoint! We collected responses from over 300 operators, with about 70% being air traffic controllers and 25% airline pilots and 5% technicians from over 25 countries. We had a good representation of female (25%) colleagues to male colleagues (75%) and a good distribution of ages and experiences with the majority being between 35 and 54 years old. Based on these data, we conducted detailed thematic analyses as well as an analysis using AI techniques to create a taxonomy of coping mechanisms and training tools.

So far, our results indicate that boredom and monotony are present within all operations, particularly amongst air traffic controllers, more so than pilots. We detected that male operators are statistically more likely to experience boredom than female colleagues but that there is no difference in the age of an operator and no cultural prevalence for boredom. This means that it doesn't matter how experienced you are or where you come from, we all get bored in the aviation industry from time to time, with males tending to be more prone to suffering from boredom-related complaints.

"Boredom and monotony is present within all operations, particularly amongst air traffic controllers, more so than pilots."

We also found that staff working as instructors or on-job trainers are far less likely to experience boredom than those not certified to act as instructors. This suggests that staff benefit from thinking about how their jobs work, actively engaging in a kind of meta-supervision of their own work from the perspective of a trainer or having learned techniques for conducting on-job monitoring of themselves and others. Or it could be simply that on-job trainers have a higher workload overseeing trainees, leading to less boredom.

Furthermore, our results confirm that:

1. Almost no operators are proactively trained either in basic/on-the-job training or in regular crew resource management recurrent training sessions, with regard to boredom.
2. There is a lack of systematic countermeasures and procedures in place to assist operators in coping with boredom.
3. With the rise of automation and demand for finer efficiency margins, perceived boredom is increasing because pilots and ATCOs have fewer tasks to do when forced by company policy to adhere to autopilot or automated tools.

So, what can we do about it? The first thing to do is to understand where boredom comes from in the operation. The following figure created from our qualitative analysis, and first presented at the European Association of Aviation Psychology (EAAP) conference in Athens, reveals the key areas that induce boredom amongst our colleagues:

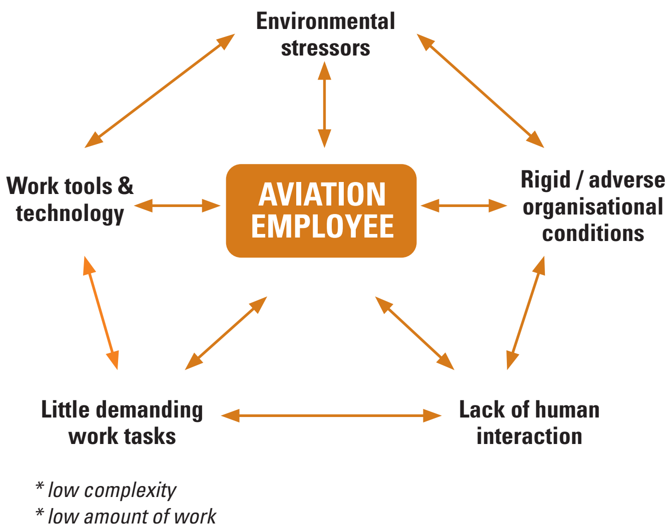


Figure 1: Where does boredom lurk and what are the main causes?

Unsurprisingly, low workload is a key factor. However, what was more surprising to us was that 'lack of human interaction' consistently featured as highly as low workload. Furthermore, environmental issues like vibrations, humming noises, light variation, temperature, and drizzle or long rainy conditions all affected the mood and feelings of boredom. Organisational conditions also featured heavily with participants regularly commenting everything from 'too many rules' to 'not enough fun allowed' as contributions to boredom.

And how do people cope with being bored? Figure 2 is a high-level view of the coping strategies and a first step in understanding what kinds of solutions could be taught to operators to help them cope. Our analysis has revealed a much more complex set of strategies that are different between pilots and air traffic controllers, which we will publish separately.

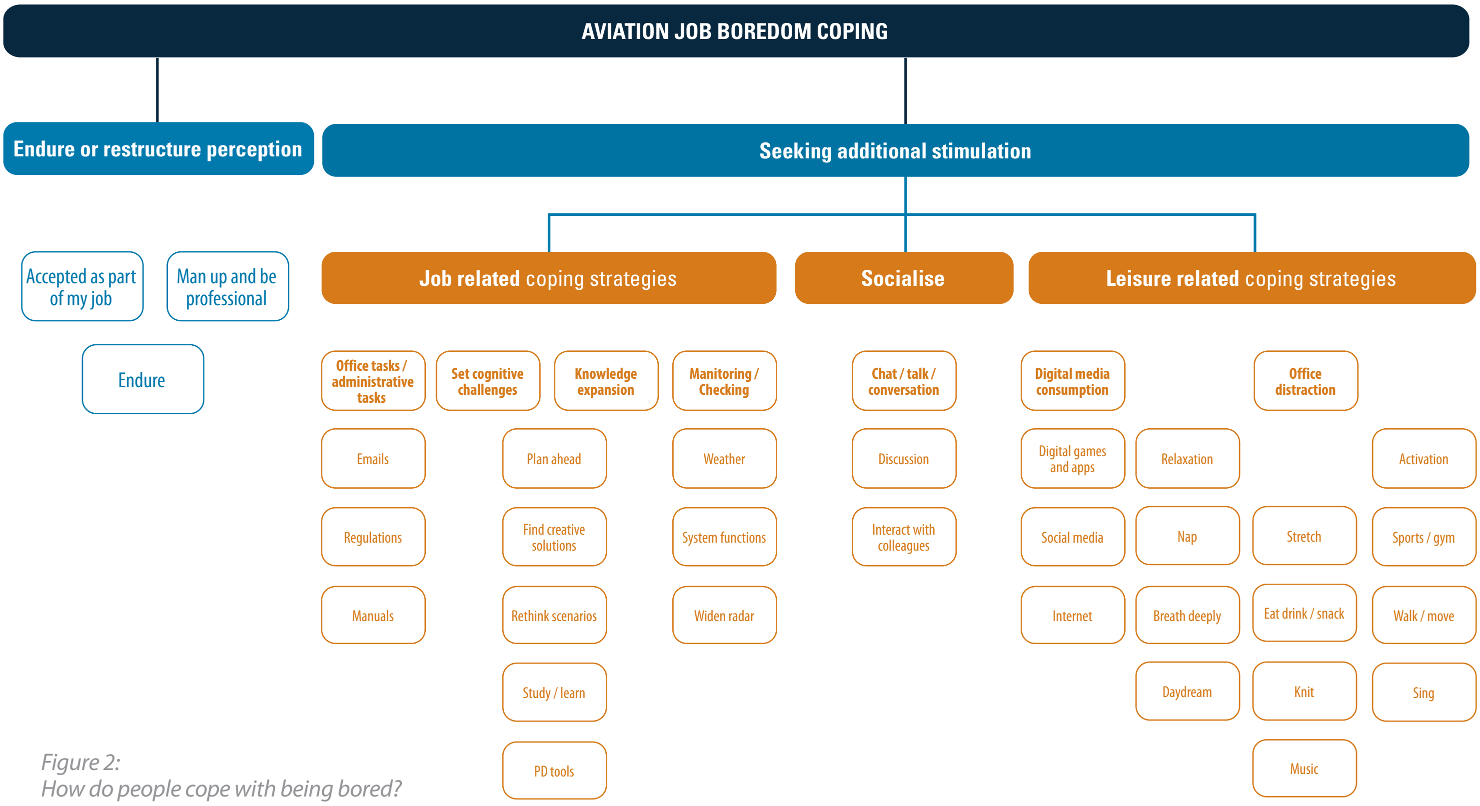


Figure 2:
How do people cope with being bored?

At first glance, many of these coping strategies should not be surprising. However, the qualitative comments revealed overwhelmingly that, in most cases, almost none of the socialising or leisure-related coping strategies are allowed in organisations. Some participants complained that some are actively forbidden such as using cell phones or talking to colleagues while on watch. Sadly, for us, some participants told us that "manning up and being professional" was about the best thing they were told to do when they were training, as well as just trying to endure and accept boredom in the job.

When we look at the literature and advice from occupational psychology, one thing we often find is that people do not just work for money. Socialising and participating in a culture that staff believe in and support are just as important as motivating factors. When staff are actively discouraged from socialising or sit in prolonged single-person operations, this not only has the inducing effect of boredom, but it also removes one of the key coping strategies and motivating factors of doing the job in the first place. This is a crucial finding in our study and should be part of all crew resource management training.

The other elephant in the room is the use of personal digital devices, like mobile phones, scrolling social media or watching films. As written in the Handbook of Fatigue Management in Transportation edited by Rudin-Brown and Filtness (2023), the use of digital devices to offset boredom and monotony is not only possible, but beneficial under the right circumstances – particularly when the situation is boredom inducing. It is better to be engaged in a cognitive task to stay in the loop than none. In fact, when battling fatigue or circadian rhythm variations, the use of digital devices may be the difference between falling asleep and staying at least partially engaged. Our study confirmed that most participants regularly use digital devices to offset boredom even when this might not be explicitly allowed. We particularly enjoyed some of the other more novel coping strategies such as knitting, crosswords and in some cases composing music!

This article has outlined some of the key findings of our study. In September 2024, we presented the comprehensive results at the European Association Aviation Psychology (EAAP) conference in Athens. We addressed the detailed thematic and taxonomy findings of our qualitative results and proposed a more thorough set of recommendations.

Our study comes at a crucial time in which new evidence is also emerging about the prevalence of fatigue across all our operations. For example, a major EASA study (2024) on fatigue has found that every extra hour in one work session increases fatigue by 33% and that night duties increase fatigue by 253% (EASA, 2024). Another study due in 2024 has also shown that highly complex operations can induce acute fatigue (measured via a reduction in reaction rates) at a much faster rate than previously assumed. When this is combined with long shift types, the risk of chronic fatigue and sleeping issues increases.

These results must be considered within the broader context of workload and boredom coping mechanisms, and we need to be far better at training and practising these strategies, especially if we are planning to introduce more automation and increase the use of single-person operations. But mostly, the lesson learned in our study is that a bored operator can be almost as problematic as a highly stressed operator and that we must do better to design our systems with this in mind.

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STAYING IN THE LOOP AS YEARS PASS

Staying in the loop isn't the same experience as we go through life. Especially as we reach more mature years, new challenges prevail, as Milena Bowman explains.

There is a post on Facebook that has been shared by many air traffic controllers (ATCOs) describing why they love the work. What struck me is that many of the posts start with *"I have worked [fill the blank: 15, 20, 30] years as an air traffic controller and here is why I love it…"*. Compare this to the average tenure in all other job sectors: 10.4 years in Greece, 8.5 years in Italy, or 3.3 years in Denmark, according to the Organisation for Economic Co-operation and Development (OECD). Most ATCOs remain ATCOs for their entire work life.

That's why it is important to speak about one diversity aspect that is rarely discussed: age. How can ATCOs 'stay in the loop' for over 30 years, and how can their organisations support them?

With pension age increasing, and ever-increasing traffic demand and complexity in air traffic management (ATM), it is important to understand how we can keep the people in safety-critical positions in the loop for an extended period of time. The longer a person relies only on the initial training and updates via continuation training, the greater the risks associated with a narrow vision of what is changing, why it is important, and awareness of the wider trends and the bigger picture. For example, many of the ATCOs at the end of their career report that they use a smaller number of the existing system features compared to the newcomers. They know the features, but they are not using them to the extent intended or expected.

> "It is important to understand how we can keep the people in safety-critical positions in the loop for many years to come."

The first few years of an ATCO's training are very intense, with a lot of theoretical knowledge and support from instructors to build up the knowledge needed for the job. From that point on, competency is mostly updated during yearly refresher trainings or upon introduction of a new feature in the system.

Given the chance, ATCOs could engage in the training of new controllers. Training ab-initios helps experienced ATCOs to connect with newcomers, update their knowledge, and revise their own habits on a peer-to-peer level. Simulator sessions provide a chance to step back from the roster treadmill and create a moment and an opportunity to reflect on ways of working. Other activities outside of the OPS room, such as safety case development, system validation, or procedure development, could also serve as a pit stop to 'top up the system', updating skills, knowledge of systems and procedures, and awareness of wider industry trends. These pitstops alleviate the effects of 'career tunnel vision'.

In addition, buddy or mentoring programmes can be very helpful. Companies with built-in flexibility in their rostering systems could create a buddy roster. For the ATCOs who do not have the opportunity or the interest to work outside OPS projects, this can also create a fantastic way to transfer knowledge and get answers to many system questions. I firmly believe in the power of mentoring to enhance the overall organisational climate, team and individual attitudes towards lifelong learning skills.

Finally, when we speak about age and ATCOs, we have to say a few words about menopause. With the increase of female participation, we now experience bigger waves of female ATCOs going through menopause. Menopause is a normal hormonal transition and most of the time it goes smoothly with manageable symptoms. Dietary habits, regular exercise and in some cases supplementary medicine help alleviate negative effects. However, for people on shifts, such as ATCOs, pilots, and shiftworking Air Traffic Safety Electronic Personnel (ATSEPs), it may be beneficial to look into changing individual shift patterns where possible. Companies should engage with their female employees to understand their needs and ways to support them.

"With the increase of female participation, we now experience bigger waves of female ATCOs going through menopause."

Sadly, we lose too many women at the end of their career because of the negative impact of menopause symptoms at the workplace (Faubion, et al., 2024).

Regrettably, ageism – the well-documented bias against older people because of negative stereotypes – often robs them of the opportunity to participate in new and exciting projects as they are overlooked in favour of young people perceived as of the 'digital generation'. Input from older people is sometimes dismissed as over-conservative and they are often excluded from innovative projects. The reality is, though, that innovation thrives when building on both creative and experienced people to bring the innovative idea to life. There is also a need for caution in innovation in the context of a safety-critical industry, and this caution may be rooted in experience of the past.

In 2023, skyguide and HelvetiCA (the Swiss controllers' association) commissioned a study to evaluate the psycho-cognitive effects of an increase of the retirement age for air traffic controllers (Baumgartner et al, 2024). The study conducted by a consortium involving EUROCONTROL, Ecole Nationale de l'Aviation Civile (ENAC), Institute Superieur de L'Aeronautique et de L'Espace (ISAE)and Welbees found no effect of age itself on ATCOs' fatigue and wellbeing, but that age had a slight effect when effects on workload were examined, and with respect to adjusting to night shifts.

The study provides three levels of recommendations to support ATCOs in working longer, safely, and sustainably. These recommendations were refined through feedback from focus groups with ATCOs and unit managers. The first is the prevention level. This level applies to all ATCOs, regardless of age, focusing on early prevention of negative effects related to work conditions. Actions include customising work schedules to fit individual preferences and enhancing predictability, especially for older ATCOs. The second is the individual follow-up level. Starting at age 35, this level introduces regular evaluations of work's impact on aspects like sleep quality, work stress, and cognitive functions. This follow-up aims to monitor and support cognitive and emotional well-being over the course of an ATCO's career. The third is the end-of-career support level. Targeted at senior ATCOs (age 50+), this level offers assistance for those who may face increasing challenges in the role. It includes reinforced cognitive screening and options to adjust working conditions, such as reduced hours, fewer night shifts, or limiting the number of licenses held. These adjustments are designed to help manage workload sustainably as ATCOs approach retirement. (See SKYbrary, 2023, for a webinar on the research.)

In conclusion, ATM organisations will benefit if they are deliberate in keeping age as one of the diversity factors in their engagement, training and human factors considerations. Organisations will benefit by engaging employees in lifelong learning skills and creating pitstops for employees to reflect, update on their working habits and connect with colleagues. They will also benefit by understanding the rostering needs of their elder population as well as what kind of activities, management practices and support are needed to keep people in the loop, having a long, safe and a happy ATCO career.

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THE BIRDS AND THE BRAINS

Captain Rudy Pont

As the aviation industry pushes toward autonomous flight, we must ask ourselves: are we ready to fully trust machines, or should we ensure that humans remain in control? Captain Rudy Pont reflects on the value of human judgment and adaptability in his encounter with a flock of birds during take-off.

KEY POINTS

- **Human qualities:** Human pilots possess adaptive, creative, and ethical decision-making skills that current automation cannot replicate, particularly in unpredictable situations.
- **Human control:** While technology has significantly improved aviation safety, it is not infallible. Pilots have to intervene when automated systems behave inappropriately and resist over-reliance on automation.
- **Joint cognitive systems:** Rather than focusing solely on reducing human error, the aviation industry should aim to optimise the joint cognitive system of human operators and automated systems.
- **Tacit knowledge and know-how:** Replacing human pilots with automation could lead to the loss of valuable tacit knowledge and experience. Frontline professionals often make small, unreported adaptations to ensure safety. This nuance could be lost in fully automated systems.

"Wind 060, 12 knots. Cleared for Take-Off Runway 04R."

With the toes on the brakes, I push the thrust levers slowly forward. Reaching 50% N1, I release the brakes and push them into the TOGA/FLX detent. *"MAN FLX 63, SRS, RWY."* My First Officer confirms with a simple *"Checked."* The aircraft starts to accelerate. 60 knots, 80 knots… What's that greyish cloud just above the runway? Are they…? *"One hundred."* Yes. Birds. Not one. Not ten. But dozens of small birds right in the take-off path…

If we perform a regular take-off, the birds will be ingested by both engines. If I hit the brakes, we should still be able to stop the aircraft, but a rejected take-off in the high-speed regime always involves risk. There's still some room underneath the flock… *"V1, rotate!"* Slowly, I get the wheels off the ground, but I deliberately stop the rotation and keep flying just a few feet off the ground. We pass underneath. Once clear, I continue the rotation and initiate a right turn to avoid the hills ahead and resume the published SID. *"Positive climb." "Gear up."* Without exchanging a single word, my First Officer understands the plan and gets us back into the standard routine.

The question is: would automation have reacted the same?
I am afraid not.

A quick search of academic articles featuring the keyword "AI" reveals that the interest in artificial intelligence has risen exponentially over the last six years. This does not come as a surprise. You probably use AI tools in your daily life, either knowingly or unknowingly, in many different web-based services. This is the digital or technological revolution. It's progress. It makes life easier, and increases efficiency and profitability.

Technology and automation have helped the aviation sector to obtain an enviable safety record. From (e)GPWS, TCAS, WX radars over enhanced monitoring systems, autopilots, FMGC, GPS, etc., progress has been slow but sure. As aviation professionals, we are sceptical of disruptive changes, because we work in a high-reliability sector. Mistakes cost lives. We say that *"standard operating procedures are written in blood".* When accidents and incidents happen, we learn from them and integrate the learning in our SOPs, training and technology. Little by little, we change things for the better, but we make sure we stay in the loop.

Unfortunately, competition is fierce and profits are thin. And the 'new' wave of digital optimism and technological developments has triggered some aircraft manufacturers to turn away from the axiom of staying in the loop. Based on the premise that technology will solve everything, some propose to remove the human from the equation. Huge investments are being made in initiatives like eMCO (extended Minimum Crew Operations) – a euphemism for Reduced Crew Operations (RCO), in itself a euphemism for Single Pilot Operations (SPO) – and autonomous flight.

I am not anti-progress. As well as a pilot, I am an engineer and an amateur developer. I love technology. But what strikes me is the obsession with seeing people as the source of all evil. Yes, humans are fallible. But at the same time, we are also adaptive, creative, conscious, and we have a sense of ethics... We do a lot of things that aren't always visible to make sure the day ends well. As organisational theorists Karl Weick and Kathleen Sutcliffe put it, *"Safety is a dynamic non-event. When nothing is happening, a lot is happening."*

As humans, we understand very well, when and how we screw up. But this underlying war on 'human error' – although nowadays sometimes nicely packaged in a just culture wrapping – keeps the idea alive that we should focus on the human element alone to make things safer. In my opinion, we should take a holistic stance and look at the joint cognitive system, i.e., the combination of technology and the human.

In 2021, I assisted in the qualitative analysis of an ECA survey asking pilots one simple question: when did you have to deviate from procedures or turn off the automation to ensure a safe outcome? From 1428 replies, 77% referred to inappropriate automated system behaviour, 12% to operational issues and 11% to inappropriate procedures. Many pilots explained how they intervened when either automation 'went rogue' or when procedures were not fit for purpose. Often – but not always – pilots had reported what happened, but were unaware whether any action had been taken to address the issue. Front liners (pilots, ATCOs, maintenance personnel, dispatchers…) don't always report when they need to adapt to a situation. After all, this is what you do as a professional. You spot an issue, you tackle it and you carry on. Small adaptations often sit in the tacit knowledge and the experience of frontline staff, remaining hidden from those more distant to the work. There is no need to report, this is part of the job. But what happens if you replace the human with automation? Knowledge and abilities get lost.

I doubt if any autonomous system would had avoided the birds like I did. To do so, an automated system would need to see (sense) the birds, risk assess the different options, then choose the ideal path. In case of a known scenario or one where we have enough data to 'teach' an AI system, this might still be feasible. The only problem is: in this complex world we don't know what challenge we will be facing next. And even when we are able to anticipate them, solutions aren't always readily available.

My plea is simple: let's look at humans as an essential resource, more than as a liability. Let's understand when and how frontliners save the day and how we render things safe and efficient with and without technology. Yes, the digital revolution will continue and systems will become more advanced. And maybe, one day, we will have enough confidence to entrust these systems with our lives. But until then, let's keep the human in the loop.

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Captain Brian Teske

STAYING IN CONTROL

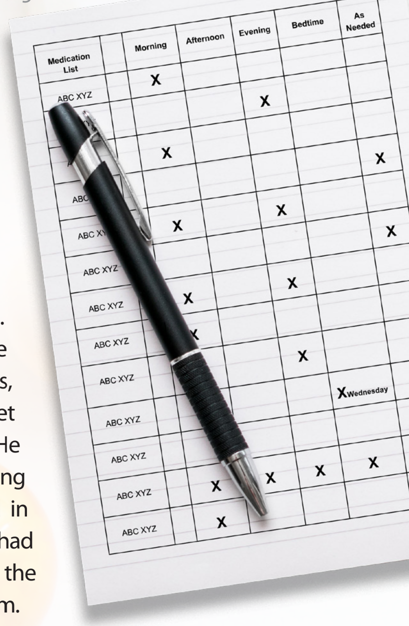
LESSONS FROM HOME

When his father returned from the hospital with new medications, Captain Brian Teske, created a detailed chart to help him stay organised. However, his father used the chart differently than expected, bringing to light simple but valuable lessons about practical versus planned implementation of procedures and policies.

KEY POINTS

- **Work-as-imagined and work-as-done:** Even with seemingly clear instructions, there can be significant differences between how systems are designed to be used and how they are actually used in practice.
- **The role of adaptations:** Frontline workers often adapt procedures to fit practical realities within safety parameters, highlighting the importance of considering user input when developing policies and tools.
- **Collaboration and communication:** Effective safety and operational procedures in high-risk environments, such as aviation, benefit greatly from collaboration and communication between different stakeholders.
- **Understanding human factors:** Understanding human factors and the variability in how individuals perform tasks is crucial for creating effective safety management systems.
- **Continuous feedback:** Continuous feedback from frontline employees, such as pilots and air traffic controllers, is essential for refining procedures to ensure they are both practical and safe.

Figure 1: Medication Chart



Recently, my father returned home from the hospital with new medications that he needed to continue taking. To help him, I created a simple chart on paper to help him to stay organised. The chart contained the medicine name, dosage, and dosage times, and I taped the chart in the cabinet as a reference tool for him. He understood the importance of taking each pill at the correct time and in the correct order and believed I had clarified the instructions using the visual chart to make it easier for him.

Confident that he understood this, I left him to assemble all the medicines for the next day, satisfied that the chart would fulfil its purpose. However, upon returning, I realised things had gone differently than planned. He did not use the chart as I had imagined. Instead, he took the chart down, placed it on the counter, and put the pills onto the grids until he filled all of the grid.

MAINTAINING CONTROL

I quickly noticed a discrepancy between my intended use of the chart and how my father had used it – my work-as-imagined and his work-as-done (see *HindSight* 25). His use produced a better outcome while remaining within my safety construct. Even with clear instructions and a seemingly straightforward system, things can go differently than planned or anticipated.

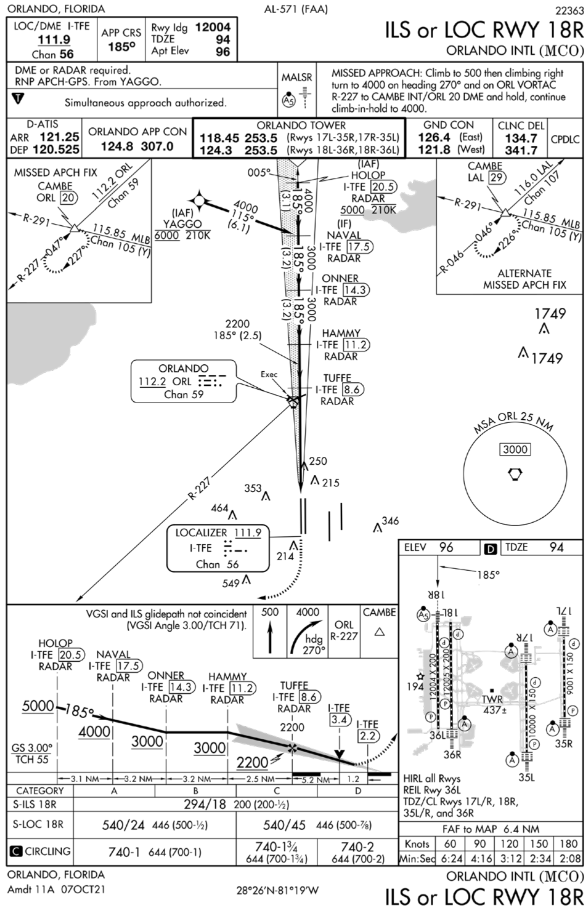
"There is often a disconnect between how policies and plans are written and how frontline staff performs the work, and between who is 'in control' of different kinds of work."

There is often a disconnect between how policies and plans are written and how frontline staff performs the work, and between who is 'in control' of different kinds of work. According to the Flight Safety Foundation's Learning From All Operations group (a group of international aerospace experts exploring how to learn from the entire operation, see https://flightsafety.org/toolkits-resources/learning-from-all-operations/), this can be common even in high-risk operations. A gap between policy and practice highlights a need to understand further how frontline individuals interact with rules and procedures. Several safety researchers have written about how gaps may arise from failing to consider workers' practical realities (e.g., Provan et al., 2020). Indeed, *HindSight* 25 explored the topic of work-as-imagined and work-as-done.

Further, the Flight Safety Foundation's Learning From All Operations group discusses the concept of adaptive capacity, or adapting to specific situations by using their knowledge base and prior experiences to make safety adjustments. Like my father's situation, in which he maintained control of his own safety situation, aerospace professionals must have the capacity to adapt their actions when dealing with specific practices, all while staying within established safety parameters. By having the capacity to make operational adjustments, organisational personnel remain vigilant to the operations while 'staying in the loop' of information and decision making.

"By having the capacity to make operational adjustments, organisational personnel remain vigilant to the operations while 'staying in the loop' of information and decision making."

STAYING IN THE LOOP: WORK-AS-PLANNED VERSUS WORK-AS-PERFORMED



Illustrative only. Not for navigation.

Frontline airline and air traffic operations workers must navigate complicated procedures and protocols daily while working with time pressures from tight schedules. Workers may be presented with the need to adjust from comfortable workflows. This is not because they are intentionally deviating from or disobeying standard operational procedures but because they need to adapt to specific operational pressures in specific context.

Several years ago, I had the opportunity to brief air traffic controllers at Orlando's Terminal Radar Approach Control facility (TRACON) on my airline's flight management system (FMS) procedures for various approaches. The discussions covered the specific aircraft in our varied fleets, mainly the details and possible difficulties of executing a last-minute visual approach. The airspace around Orlando presented challenges on runway 18R due to a nearby airport underlying the ILS approach path, requiring a higher initial altitude and increasing the possibilities of unstable approaches and go-arounds.

Throughout my week there, I worked closely with the various TRACON team members to discuss our approach operations and clarify pilots' decision-making processes when given time-compressed instructions.

This engagement developed into a collaborative problem-solving and data exchange. It provided an opportunity for hands-on team building and to discuss a formalised departure sequence program, integral for coordinating departures between the airlines and ATC sectors. This exchange went beyond procedures; it reinforced the symbiotic relationship that helped to ensure smoother operations in the skies around Orlando. The dialogue enhanced our collective understanding and coordination between my airline and air traffic controllers, focusing on safety and efficiency, and offered a glimpse into the many complexities of each other's jobs.

"Controlling air traffic is both an art and a science, much like flying."

What fascinated me most during these interactions was the reminder that controlling air traffic is both an art and a science, much like flying. Contrary to my conception of ATC uniformity from initial primary flight training, the controllers discussed their unique air traffic control style. Their methods of controlling not only varied between different controllers, but were customised depending on the context, especially outside the Standard Terminal Arrival Routes (STARs) followed by aircraft on an instrument flight rules flight plans prior to reaching their destination. Understanding the localised ATC best practices allowed me to anticipate their workload better and make minute operational adjustments when flying in this airspace. Work-as-done varied by person and context, and this variability was essential to staying in control.

Additionally, as pilots, we often try to anticipate the needs of air traffic control flow to ensure a smooth transition during the flight. This interaction between pilot and controller, which varies from airport to airport, further highlights the complexity of aviation operations and the interactivity involved in all of us staying in control.

Responsibility for addressing the challenges faced by frontline employees rests with the leaders inside the aerospace industry. Management should encourage employees' involvement in policy and procedure formulation.

According to the International Civil Aviation Organization (ICAO), a frontline employee communication component of a Safety Management System (SMS) is an anonymous Aviation Safety Action Program (ASAP) that allows employees to address operational and safety issues. Pilots, controllers, and others contribute by sharing their experiences and providing insights into the complexities of operations. Incorporating these data as a communication feedback loop can help inform policymakers of events that combine tacit knowledge, helping to bridge the gap between 'ideal' policies and required practical implementation (see Barshi et al, 2017).

My experience with the method of my father's use of the medication chart and the insights gained from the Orlando controllers about their customised controlling methods brought to light an interesting truth about human factors and system safety. Whether personal or professional, a gap between others' planned intent and one's own actual performance can exist and may be challenging to uncover. My father's modification to the medication chart as a stencil rather than a reference brought to light the user's imagination. Despite understanding the theoretical implications, I created a procedure in a vacuum without practical knowledge of using the process. Much like the ATC personnel I chatted with, they all maintained control of their practices while maintaining the information loop. Policies should be crafted and revised with frontline users' input and experiences. Research and feedback from pilots and controllers through programs like ASAP are invaluable, ensuring that policies are practical guidelines shaped by the realities of daily operations.

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STARTLE & SURPRISE MANAGEMENT

Startle and surprise management are essential for staying in control. Building on previous research, James Blundell, Jeroen van Rooij, Annemarie Landman and Daan Vlaskamp present an operational evaluation of a self-management method designed to mitigate the cognitive and physiological impacts of these responses, offering new insights into its effectiveness in flight.

- **Startle and surprise:** Startle is a reflexive response to intense stimuli, while surprise is a cognitive-emotional reaction to unexpected events. Both can impair pilot performance, decision-making, and communication, and can occur together.
- **The Reset method:** A self-management method called "Reset" was evaluated, which helps pilots recover from startle and surprise. It involves physical distancing, breathing techniques, muscle relaxation, and checking the well-being of fellow crew members.
- **Pilot experience:** Pilots found the Reset method useful for managing stress and improving situational awareness, with the breathing technique and checking on colleagues being the most valued steps.
- **Challenges:** The main challenges in applying the method included the urgency to act during emergencies, difficulty admitting being startled or stressed, and environmental factors such as noise and turbulence.

A previous issue of *HindSight* (issue 34) was dedicated to the handling of surprise, caused by unexpected events. Surprise is a cognitive-emotional response triggered by a mismatch between our expectations and reality, such as unexpected automation behaviours, which endures for as long as a cognitive mismatch persists.

"While distinct, startle and surprise can occur together and both produce incapacitating cognitive and physiological effects that impair pilot performance, communication and decision-making."

On the other hand, startle is the far more transient reflex-like response to intense physical stimuli that can be triggered by both expected and unexpected events (definitions adapted from https://dictionary.apa.org/startle-response). While distinct, startle and surprise can occur together and both produce incapacitating cognitive and physiological effects that impair pilot performance, communication and decision-making (Martin et al., 2016). Both are thought to have contributed to aviation incidents and accidents.

HindSight 34 featured two articles on recent research into startle and surprise self-management methods for pilots, which can help mitigate the related cognitive and physiological impairments and expedite the recovery of performance. Simulator research has shown that these methods can improve pilot decision-making performance and are considered useful by pilots (Field et al., 2018; Landman et al., 2020). In this article we present follow-up research, consisting of the first evaluation of such a method in operational practice.

The evaluated method is based on the method detailed in the article 'Training for Surprises', in *HindSight* 34. The method does not distinguish between startle and surprise. Both often present simultaneously, and pilots regularly do not distinguish between

the two themselves. Thus, the method is intended to support recovery from startle, surprise, and the two together.

Ten pilots of a major European airline were interviewed about their startle and surprise (S&S) experiences in real-life and training experiences. In addition, pilots described their experience with applying the startle and surprise management method, which their airline had implemented since 2018. The method is part of a wider 'non-normal strategy', which places the method after the steps of 'protecting yourself' (e.g., donning an oxygen mask) and bringing the flight path under control. The method itself is called 'Reset' and consists of the following 5 steps:

1. Announce to the other crew member(s) that a 'Reset' will be performed.
2. Take physical distance: push back into the back of the seat.
3. Perform an abdominal breathing technique: take a deep breath, and exhale slowly. Repeat if necessary.
4. Tighten and relax muscles.
5. Check the wellbeing of the fellow crew member(s).

The method is followed by systematically building situational awareness, by calling out all observed indications of the problem. The aim is to avoid rushed decision-making. Transcripts from the interviews were analysed using thematic analysis. This produced five themes that summarised the discourses with the pilots, described below.

EFFECTS OF STARTLE AND SURPRISE

Pilots reported both physical effects (e.g., increased heart rate) and psychological effects (e.g., tunnel vision) during startle and surprise. *"You feel the adrenaline"* said one pilot. Some described surprise experiences were associated with significant distraction: *"having [no] control over … thoughts and the stress that caused"*. A pilot described surprise in his colleague: *"he felt a bit stuck"* and *"I had to pry the information out of him"*.

Startle and surprise were not often experienced in the simulator, as non-normal situations are expected, sometimes *"scenarios are known in advance"*, and the simulator feels more *"artificial"*.

BENEFITS OF USING THE RESET METHOD

All interviewed participants were positive about the Reset method and most had used it. Participants said that they found it effective, and one noted that it *"helps to find calmness"*. Benefits in perception and comprehension were reported. For example: *"we noticed a warning light that we didn't notice before"* and *"it felt like my brain was plugged in again."*

An unexpected benefit was the method's general stress management application. It was reported to be useful during: *"a busy day with lots of disturbances on the ground"* and in a *"dense fog situation at home base."*

ELEMENTS OF THE METHOD USED

Pilots did not always use the full method. "*We didn't call it startle and surprise. We just asked, 'are you ok?'*" said one participant. The element that was reportedly least used was the "tense/relax muscles" step. Most used were the breathing technique and the step "check colleague". Supporting Field et al. (2018), this element is valuable in several cases where a colleague is startled or surprised and crew situation awareness was compromised: "*I asked how are you? And then I realised this event startled him a lot…. He thought this was all [his] fault. … If I hadn't asked this question, we would have remained [a] 'split cockpit'. … He was still too focused on what was going on.*"

BARRIERS TO USING THE METHOD

Some pilots noted difficulty admitting being startled, surprised, or stressed, for fear of being seen as incompetent: *"It is a bit of a tough-guy culture"*, said one participant. In addition, a desire to take quick action, rather than employ the method, was a recurring comment: *"It feels that valuable time is lost"*, said one pilot, and another noted, *"you are so full of adrenaline and stress that I don't see where to fit it in."*

"Some pilots noted difficulty admitting being startled, surprised, or stressed, for fear of being seen as incompetent."

Interference from environmental factors (e.g., noise disrupting verbal communication) were highlighted by two participants. In one case, strong turbulence at low altitude was mentioned: *"If it's so turbulent that you can't read the instruments, I don't know if you can do a reset."*

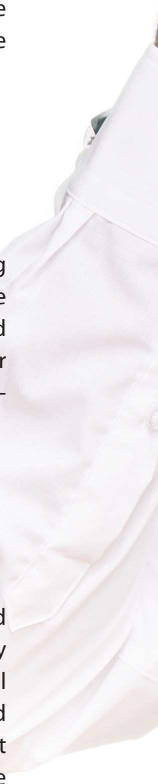
The opinion that the method was associated more with startle than surprise was voiced. *"Perhaps it's overkill for surprise."* This may be due to surprise having no clear 'trigger', which makes it hard to recognise. Also, pilots often used the terms interchangeably, so this observation should be treated with caution.

TRAINING

Simulator upset recovery training was voiced as being a situation where exercising the method was difficult due to not being sufficiently addressed: *"I've never seen it used"*, said one instructor.

Based on simulator experiences, the procedures following decompression (emergency descent) were felt to leave little room for performing a Reset: *"In case of a decompression, it is fine to be startled, but you really have to go down as quickly as possible, especially when at FL410."* It is a complicated procedure for a situation that usually occurs suddenly, unexpectedly and with a startling or surprising stimulus (such as a cabin warning horn or a bang), where several memory items must be performed and where communication is hampered by oxygen mask use and the potential of hypoxia.

Pilots mentioned possible training improvements about S&S recognition in oneself and, importantly, in the other pilot. Also, *"sharing real experiences"* and having fellow pilots recount the benefits of using the method in actual emergency situations were suggested as approaches to address resistance in training.



FOLLOW-UP RESEARCH

After the interviews, a questionnaire survey was conducted among the company's pilots. Its findings confirmed the results from the interviews. In brief, 239 pilots responded and 91% had experienced startle or surprise during a flight. Eighty seven percent felt better prepared for S&S situations and 39% had used the method in real-life S&S situations.

CONCLUSION

Both the interviews and survey confirmed previous simulator-based research that S&S management methods are much appreciated by pilots, and are perceived to reduce stress and improve situational awareness and decision-making. Critically, no pilot reported experiencing negative effects from using the method. The most useful elements of the tested method were the breathing technique and checking the mental state of one's colleague. Following up with careful building of situation awareness is an important next step.

The main barrier to using the method during actual flight operations was the urge to take immediate action. A threatening stimulus takes priority over performing these methods through the human urge to eliminate the threat. This can impair perceptual processes and cause cognitive tunnelling. It can also increase the likelihood of incorrect and rushed decisions (Field et al., 2018).

"The paradox of startle is that the higher the stress level and the more a management method is needed, the more difficult it becomes to initiate a method."

The paradox of startle is that the higher the stress level and the more a management method is needed, the more difficult it becomes to initiate a method. The reported difficulty in recognising the effects of startle and surprise might also be a consequence of this effect. This reinforces the importance of the step of checking the fellow crew member's mental state.

As startle and surprise are a common occurrence, a well-trained self-management method is a very useful tool for pilots to have.

TRAINING RECOMMENDATIONS:

- The effect of the 'startle paradox' during pilot training of startle and surprise management methods should be explained to pilots: the more stressful a situation is, the stronger the urge to skip these methods.
- They should be trained in a variety of difficult situations, to emphasise appropriate timing, especially in situations that require urgent action.
- When introducing startle and surprise management methods, they should be kept simple and short, as they have to be performed in situations with a high cognitive load.
- For upset recovery training, using the method post-recovery will prepare pilots for possible subsequent events by diminishing the detrimental cognitive effects from accumulated stress (Landman et al., 2020). A thorough introduction (see *HindSight* 34) will help with acceptance.

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Nippin Anand

CAN PEOPLE IN CONTROL LOSE CONTROL?

SURFACING THE MYTHS WITHIN NARRATIVES

After the Costa Concordia accident, the captain was vilified for failing to live up to society's expectations of people in control. In this article, Nippin Anand challenges the prevailing narratives surrounding this and other accidents, revealing myths that shape our understanding of human behaviour during crises, especially in situations of traumatic stress.

KEY POINTS

- **Societal myths in a crisis:** Human pilots possess adaptive, creative, and ethical decision-Prevailing narratives about the Costa Concordia disaster highlight a societal tendency to create myths around tragic events.
- **The compliance myth:** Societal myths influence perceptions of individuals in control in high-risk industries during crises. The compliance myth emphasises rule-following, while the defiance myth glorifies defying rules to establish order during crises.
- **Freeze mode and decision making:** Traumatic stress can lead individuals in crisis situations to enter a 'freeze mode', affecting their decision-making abilities.
- **Empathy and support:** Societal expectations of individuals in control during crises should be reconsidered to foster a more empathetic understanding of human behaviour and to provide adequate support structures for those experiencing traumatic stress.

On the 13th of January 2012, the Costa Concordia ran aground off the Giglio Islands in Italy, resulting in the death of 32 people. One issue that stood out to me in this accident was that the captain became the 'main cause' of the accident. If, like most people, you think this was because the captain came too close to the shoreline, he abandoned the ship 'too late', or he deserted the ship before all the passengers were evacuated, then you are not alone, and these beliefs reflect media reporting.

But the allegations made against the captain were far from the truth. Reflecting on the work of the French philosopher Rene Girard, these are myths that give meaning to misfortune. Girard asked a somewhat obvious but provocative question: can't you see it is a myth when an entire society uncritically embraces such narratives without asking a single question?

But we are neither the mob nor 'average people'. We are professionals working in high-risk industries. Given the theme of this issue of *HindSight* – People in Control – it may be appropriate to begin by asking how our society thinks about people in high-risk industries. For this article, 'people in control' would mean people in charge of making decisions about the day-to-day operations of high-risk systems. This would include pilots, surgeons, ship captains, nuclear power plant operators, drilling engineers, oil refinery managers, and many more. These professionals are typically closest to the hazards in time and space, and while they are somehow 'in control', control is distributed in many parts of the system. So, we should try to understand what gives meaning to such myths in our society about 'people in control'. One day, it could be us in lieu of Captain Francesco Schettino.

One way to approach this accident is to falsify the myth. I could take you through the details of the court proceedings, my interviews with the captain of the ship, academic articles, and books to help you understand that what we have heard so far about the captain's behaviour is far from the truth. I recently published a book that comprehensively discussed this incident, called Are We Learning From Accidents? But I will deliberately choose not to follow this path of falsifying the myth. Rather, let us turn the question around and ask ourselves: *"Why does the 'Captain Coward' myth appeal to us as much as it does?"*

There are at least two dominant myths in the Western society to understand human behaviour: **the compliance myth** and the **defiance myth**.

THE COMPLIANCE AND DEFIANCE MYTHS

The compliance myth is that accidents happen because people fail to follow rules. 'Rule following' and 'duty of care' are common expressions. In an accident, we are quick to point out which rules were breached, and which procedures were not followed without becoming too concerned with the contextual relevance of those rules. That is also how we think about the behaviour of people in control in a crisis – compliant or non-compliant.

The defiance myth is that people create order in the midst of chaos, even if it means defying the rules. People in control are judged based on their ability to fight against the odds to lead us to salvation. In the defiance myth, there are both heroes and anti-heroes fighting against each other. The hero's job is to liberate the oppressed from the oppressor and ensure justice in the society. Life is a struggle centred on the premise of competition, success, growth, and intellect.

Stories of both myths are linear – 'once upon a time' with a happy or unhappy ending. The problem is that most people who have lived through a crisis do not fit neatly with the compliance myth or the defiance myth. Life is not as straightforward as following the rules or going against the odds to produce safe outcomes.

"In a crisis, especially in a potentially traumatic situation, people do not always fight or flee. In the case of the Costa Concordia, the captain experienced a state of freeze."

In a crisis, especially in a potentially traumatic situation, people do not always fight or flee. In the case of the Costa Concordia, the captain experienced a state of 'freeze' (see van der Kolk, 2014).

A TRAUMATISED CAPTAIN

Various official and media reports illustrate that on the night of the accident, the captain was experiencing traumatic stress:

"After hitting rocks which tore a 70-metre-long hole in the side of the Costa Concordia, Schettino rang Roberto Ferrarini, an official manning the company's emergency room. In a recording of the conversation, the court heard him say, 'Captain Palombo told me, "Pass by, pass by!" I passed by and hit the bottom with the stern. I am destroyed, I am dead, don't say anything to me."' (Kington, 2013)

"First mate Giovanni Laccarino said that the Captain put his head in his hands and told the officers on the bridge: 'I messed up.' During the trial, Mr Laccarino told the court that he was using his Playstation in a crewmate's cabin when the ship hit the rocks. He rushed to the bridge, where instruments showed that the ship had lost propulsion, but was surprised at the captain's calm demeanour.' He was completely lost,' he said. 'He was out of his routine mental state. He was under shock. He wasn't the person I knew.'" (Winfield & Sportelli, 2013)

"Ms Canessa, the navigator, also said Captain Schettino showed chronic indecision as he contemplated the loss of his ship. 'I was saying to him very insistently that he needed to do something, to give the general emergency signal, but he was telling us to wait,' she told the court, 'even as officers screamed at him to do so', said Canessa. 'He told us to wait, he didn't give us answer,' she said." (Kington, 2013)

In an interview with the Naples daily newspaper Il Mattino, Gianluca Marino Cosentino, the medical officer on board the Costa Concordia, also mentioned the long delay before abandoning ship and accused Schettino.

"Everyone was looking for the captain. As a doctor, I thought he appeared upset and no longer rational. He did nothing to coordinate the rescue. Personally, I was very surprised to see Schettino out of uniform on the quayside after midnight." (Lloyd, 2019)

DECISION MAKING IN A CRISIS

In a crisis, decision making is a dynamic, continuous process of sensemaking. Moment by moment, as we build a coherent picture of the past by giving meaning to our experiences, we are also faced with a future full of novelties and surprises. During the crisis, as the captain was working out the extent and location of the damage to the ship, new information was being brought to his attention by his team. This information was sometimes unclear or misrepresentative, and on other occasions conflicted with

"In a crisis, decision making is a dynamic, continuous process of sensemaking."

Francesco's own beliefs and identity as a captain. Under extreme stress, our experience of time can be distorted. What we hear and see starts to conflict with our goals, threatening our identity and even our existence.

Interestingly, when a ship is on fire or sinking, we often use the metaphor 'ship in distress'. But only living beings experiencing distress. Under traumatic stress, our life support systems – nervous, respiratory, endocrine, digestive, skin, and cardiovascular – all begin to tell each other that something is not right. Then, when our homeostasis is out of balance, our emotions become disconnected from our reasoning abilities.

CAN PEOPLE IN CONTROL LOSE CONTROL?

A question that comes to mind is that despite all the evidence suggesting that the captain was suffering from trauma, and knowing that decision making is severely impeded in a trauma, neither the public media nor the official report refers to the captain's state of mind during the crisis. In fact, as I sift through many other examples of maritime accidents, trauma and distress are rarely acknowledged in accident investigations. Why is this?

"Society – seduced by the myths of compliance and defiance – finds solace in scapegoating a professional rather than attempting to understand a person's psyche."

Perhaps it is because a society – seduced by the myths of compliance and defiance – finds solace in scapegoating a professional rather than attempting to understand a person's psyche. A narrative that depicts a captain in distress does not sound like a superhero myth - a captain in uniform, working out the optimum move in the midst of a crisis, with everyone around the captain doing exactly what the superhero expects. Captain Francesco Schettino absorbed all the sins of our society in terms of design, regulation, operating standards, and the insatiable demand for cheaper, better, safer cruises. Instead of being a superhero who could absorb all the flaws of shipbuilding and operations, he 'allowed' distress and trauma to take over his decision making.

I am left with more questions than I have answers. Where was the support for the captain? Where were the structures to help him in the traumatic situation and with traumatic stress? What culture had been cultivated on the bridge? Why are people in control expected to be superhuman in a crisis? What kind of culture has been created such that captains can't listen to others below them in the hierarchy? These are questions far beyond the scope of simplified stories of compliance and defiance.

REFLECTIONS

Understanding human behaviour does not come from some objective reality out there woven into timelines, evidence and factual reports. These are narratives that we create, share and believe to give meaning to human suffering, and they contain hidden myths. Perhaps we can learn to be more understanding, empathetic and forgiving, and less judgmental about people in control when they lose control.

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Mark Young

STAYING IN CONTROL

THE PROBLEM OF MENTAL UNDERLOAD

Mental underload is closely tied to the idea of staying in the loop, and is critical in situations where people are a backstop for automation. In this article, based on a recent webinar, Mark Young explains this often-misunderstood concept, and some implications for safety and performance.

KEY POINTS

- **Low cognitive engagement:** Mental underload occurs when tasks are continuous and essential but offer very little demand, resulting in insufficient cognitive engagement.
- **Impaired performance:** Underload can significantly impair performance. When underloaded, attention degrades, monitoring is affected, and reactions slow down, increasing the risk of missing information and responding inadequately.
- **Passive monitoring:** Automation often leads to underload by relegating people to passive monitoring roles. Prolonged periods of low cognitive engagement can leave individuals ill prepared to handle sudden spikes in demand, such as system failures or situations requiring human intervention.
- **Methods to understand mental underload:** Several methods help assess mental underload. These include monitoring performance on the primary task and secondary tasks, subjective ratings of perceived workload, and physiological measures.
- **Mitigation strategies:** Strategies to mitigate the risks of mental underload include periodically reintroducing manual control, incorporating related secondary tasks to maintain engagement, and redesigning systems to minimise prolonged periods of low workload. A more radical proposition involves waiting for fully autonomous systems to be viable.
- **Future research and practice:** Future research and practice should focus on understanding the dynamics of attention decay and recovery during underload, developing more precise measurement tools, and designing systems that balance automation with meaningful human engagement.

INTRODUCTION

Mental underload is something that many operational *HindSight* readers will have experienced, and a concept that I've explored since the start of my career in Human Factors nearly 30 years ago. My own experience mainly comes from two sources: research on driving automation, and practice as a railway accident investigator, concerning train automation. This combination of experience has shown me how underload can leave individuals ill prepared to detect and perceive critical information, or to handle surprises in critical moments.

Underload is closely related to the ideas of people in control and staying in the loop, especially in environments that are high tempo and demand constant monitoring, like transportation. But the concept remains widely misunderstood. In this article, I'll explore what mental underload really is, how it affects performance, and, most importantly, how we can address it from individual and organisational perspectives.

WHAT IS MENTAL UNDERLOAD?

Before we get into the theory, consider these three accidents which brought mental underload into the public eye in the space of two years. In 2016, a tram derailed on a sharp curve in Croydon, South London, tragically resulting in seven deaths. The driver had just navigated a long, straight section of track that required minimal interaction. The tram entered the curve at 73 km/h – well over the 20 km/h speed limit – and overturned. The investigation suggested that the monotony of this part of the journey created an underload state that may have caused the driver to lose awareness, with disastrous consequences.

In 2018, a passenger's bag became caught in the doors of a Central Line underground train in London, leading to them being dragged along the platform. The train operator did not notice the trapped bag. While the Central Line is largely automated, drivers are still responsible for opening and closing doors and monitoring the platform through CCTV before departure. The repetitive nature of this work, with frequent stops and highly automated operations, contributed to underload. While the passenger survived, the incident showed how repetitive tasks can reduce attention, even in highly experienced operators.

During Uber's 2018 test of autonomous vehicles in Tempe, Arizona, a vehicle equipped with sensors designed to detect objects failed to classify a pedestrian walking a bicycle across the road. Although the system detected an object, it couldn't decisively identify whether it was a pedestrian or cyclist. By the time the system responded, 1.2 seconds before the collision, it was too late to avoid the accident, resulting in a fatality. A critical element of this scenario was the presence of a 'safety driver', whose role was to monitor the automated system and intervene if necessary. However, this task had become so undemanding that the driver disengaged, reportedly watching a TV show on their phone.

What the three examples have in common is that mental underload usually occurs in tasks that require some constant engagement, such as driving, but in which the demands are excessively low, leading to a lack of mental stimulation and consequently affecting our attention.

But to understand mental underload, we need to step back and consider its relationship to mental workload more generally. Mental workload refers to the cognitive resources we dedicate to a task, and this depends on our attentional capacity. It's the balance between the mental effort we exert and the demands of the task. While overload results in an overwhelming cognitive burden, underload results in cognitive disengagement. Effectively, our attention 'shrinks' when it is not being used.

"While overload results in an overwhelming cognitive burden, underload results in cognitive disengagement. Effectively, our attention 'shrinks' when it is not being used."

It might seem counter-intuitive, but underload can be just as dangerous as mental overload. The effects of underload can be subtler, however, potentially leading to a decline in performance over time. This might include difficulty in detecting, perceiving or understanding what's going on in a situation, and slower reaction times or inappropriate responses.

Several related concepts are frequently confused with underload. Here are some of the key things that underload is not:

1. Doing Nothing: Underload doesn't mean inactivity. A classic example is when individuals supervise automated systems, such as in flying or driving. Automation may handle most of the workload, with the human operator having to monitor and intervene if necessary. In these cases, the operator is facing a very low demand – but there is still a need to stay engaged.

2. Boredom: While underload can feel unstimulating, it's distinct from boredom, which is defined by the American Psychological Society as *"a state of weariness or ennui resulting from a lack of engagement with stimuli in the environment"*.

3. Automatic processing: As individuals become highly proficient in certain tasks, their actions can become automatic, like driving a familiar route without much conscious thought. While this may require little mental effort, it's not the same as underload. Skilled performance still allows for rapid, effective responses to changing conditions, whereas underload tends to reduce the ability to respond.

4. 'Complacency' and over-trust: This often occurs when someone becomes overly reliant on automation or believes a system is so reliable that they no longer need to monitor it carefully. This is a natural response to highly reliable systems.

WHY AND WHEN DOES UNDERLOAD HAPPEN?

Research has shown that the underload 'problem' is predominantly tied to automation, as tasks without automation – even easy ones – often still require some active engagement, making it harder to fully disengage mentally. Automation is often designed to handle repetitive or routine tasks, leaving the operator in a supervisory role. This reduced level of task engagement can lead to mental underload. The operator's job becomes one of passive monitoring, which may lead to periods of low mental activity and a potential drop in alertness and readiness to intervene.

Many automated systems are designed to function at a very high level of reliability, and rarely require human intervention. This reliability further deepens the underload state, because interventions – which increase workload and can restore attention – are few and far between. When technical malfunctions occur, or when a system encounters a situation beyond its capability, there is a sudden transition from passive monitoring with low cognitive engagement to active problem-solving with high cognitive engagement. This sudden shift is particularly dangerous because it can overwhelm the operator.

"When technical malfunctions occur, or when a system encounters a situation beyond its capability, there is a sudden transition from passive monitoring with low cognitive engagement to active problem-solving with high cognitive engagement."

WHY DOES UNDERLOAD AFFECT PERFORMANCE?

To understand this, we need to look at the relationship between stress, arousal, and performance. This is often depicted as an inverted U-shaped curve. The basic concept dates back to 1908, and shows that performance is optimal when stress and arousal levels are in a balanced, moderate range. However, both excessive stress (overload) and insufficient engagement (underload) affect performance negatively.

When workload is too high, demands exceed cognitive resources. But when workload is too low, as in underload, performance declines due to lack of stimulation. In low-demand scenarios, our attention declines, affecting monitoring and engagement, leading to missed cues and slower reactions. To balance overload and underload scenarios, it is important to maintain a state where attentional demands are sufficient to keep operators mentally engaged without overwhelming their capacity.

Traditional models treat our attentional capacity as a fixed and finite resource. Picture it as a bucket with a fixed volume; as task demands increase, the bucket fills, but once it overflows, performance drops off. These models don't account for how underload, or low task demands, can also lead to performance issues.

I developed the 'malleable attentional resources theory' in response to this (Young and Stanton, 2002). It proposes that attentional capacity can expand or contract in response to the demands of a situation. In low-demand situations, our brain may artificially lower its ceiling when it comes to attention. As a result, our performance capacity decreases, even though we are not being overwhelmed by external demands. In higher demand situations, our attentional resources can expand to meet the task, but under low demand, attentional resources shrink, making it harder to respond to unexpected spikes in task difficulty. What might be within our capacity to cope under normal circumstances soon becomes out of reach when demands reduce.

This theory explains why underload, especially in highly automated environments, can impair performance. For example, if a driver or pilot in a high-demand scenario faces a sudden system failure, their attentional capacity may be high enough to respond effectively. However, in a low-demand, highly automated scenario, the same person's attentional capacity may have diminished, leaving them unprepared to handle the same event. The task demands remain constant, but the operator's ability to cope has dropped, leading to performance failure.

HOW CAN WE MEASURE UNDERLOAD?

There are various methods commonly used to assess mental workload. These approaches help us understand how much cognitive capacity is being used during a task and how much spare capacity remains, particularly when tasks are too easy, or automation reduces human involvement. The following four methods are the main types used in research and practice.

Primary Task Performance

The simplest way to assess workload is by monitoring performance on the main task. For driving, this could involve metrics like lane position, speed control, and steering stability. The problem is that primary task performance alone cannot always detect subtle differences between moderate workload and underload. Performance may remain stable at each of these levels of demand because they are both within the operator's capacity. So we need a way of distinguishing these tasks by measuring leftover capacity.

Secondary Task Performance

To capture 'spare cognitive capacity', secondary tasks are often introduced. These tasks are only performed when participants have leftover attentional resources. In driving studies, an example secondary task involves mentally rotating figures and determining via a button press whether they are the same or different. This task competes for the same visual and spatial resources as driving, and so helps to assess how much cognitive capacity is left. If fewer responses are made on the secondary task, it indicates a higher workload on the primary task. In underload situations, more responses on the secondary task are expected because more spare capacity is available.

Subjective Ratings

Subjective measures like the NASA Task Load Index (NASA-TLX) are often used in Human Factors to assess workload. Participants rate their perceived workload on various dimensions after completing a task.

Physiological Measurements

Various physiological metrics provide data on mental workload. For instance, heart rate is a measure of physiological arousal, and can be linked to workload. As workload decreases, so does arousal, and vice versa. More advanced methods are emerging as potential ways to measure brain blood flow, offering a possible direct measurement of attentional capacity. While still developing, these tools could help detect when attentional resources are diminishing due to underload.

Attention Ratio and Malleable Resources

In my research, I've used a combination of secondary task performance and eye tracking to develop an attention ratio measure. This ratio reflects how much time participants spend on the primary task versus the secondary task. By comparing the time spent and the number of responses on the secondary task, we can infer the degree to which attentional capacity has diminished in underload conditions.

Some researchers have proposed a 'red line'. This is a hypothetical boundary beyond which underload or overload begins to affect performance. Defining this precisely remains a challenge. Each person's cognitive limits vary, making it difficult to pin down a universal threshold. However, it's clear that once mental workload drops below a certain point, performance suffers.

Workload is influenced by various factors, such as task difficulty, teamwork, automation, and individual skills or experience. This can make it difficult to understand which aspects of workload we are measuring when conducting research in this area.

DECAY AND RECOVERY OF ATTENTION

A critical aspect of underload is how quickly attentional capacity decays during periods of low demand and how rapidly it can recover when task demands increase. My analysis has shown that attentional capacity decays quickly, typically within the first minute, after a period of low demand. This decline is critical, especially in tasks like driving, where a relatively short span of low workload can leave people unprepared for sudden, urgent and critical demands.

"A critical aspect of underload is how quickly attentional capacity decays during periods of low demand and how rapidly it can recover when task demands increase."

In one of my studies conducted using a driving simulator, participants experienced two driving conditions: one with partial automation, where only the speed and distance to the car in front were controlled by adaptive cruise control, and another with full automation, where both speed and steering were automated. In the fully automated condition, the driver's role shifted to that of a supervisor, monitoring the system's performance rather than actively controlling the vehicle.
The problem arose when the system encountered a failure. In this scenario, the car in front began to slow down, but the automated system failed to adjust the vehicle's speed accordingly. The driver had to recognise the failure quickly, take over manual control, and brake to avoid a collision.

The simulation revealed, not surprisingly, that skilled drivers were able to respond more effectively compared to less experienced drivers. Even though both groups had been in an underload state due to automation, skilled drivers had an automatic, unconscious response to hit the brakes, developed from years of driving experience. This response was less likely in less experienced drivers, resulting in a higher likelihood of collisions.

Recovery from periods of low demand is an area still under investigation. Research in driving suggests that while technology aims for quick recovery times (ideally 10-15 seconds), full re-engagement in a task can take up to a minute. This delay poses significant safety challenges, particularly in scenarios where automation temporarily hands control back to a human operator; in semi-automated driving, even a few seconds is too long. Understanding the dynamics of both decay and recovery is crucial for designing systems that ensure operators remain sufficiently engaged and ready to act when needed.

HOW CAN WE GUARD AGAINST MENTAL UNDERLOAD?

Mental underload can be just as dangerous as overload, particularly in automation-heavy environments. When someone becomes disengaged, they are more prone to missing critical cues or responding too slowly when something unexpected occurs. The challenge, then, is to ensure attentional resources are maintained at an optimal level. Here's how we can guard against underload and even explore how it might be exploited in specific contexts.

"I'm very much an advocate of designing out these problems in the first place. This avoids putting the onus on front-line personnel to deal with underload."

First, and most importantly, I'm very much an advocate of designing out these problems in the first place. This avoids putting the onus on front-line personnel to deal with underload, and is consistent with an ergonomics-oriented approach of fitting the task to the person. Underload shouldn't be their problem.

A common method of maintaining attentional engagement involves periodically reintroducing manual control in highly automated environments. This approach was recommended following investigations into accidents. Periods of manual control help to keep operators engaged, while also allowing automation to relieve cognitive demands when appropriate. Used carefully, it can also help to stabilise mental workload rather than cycling through peaks and troughs (although it is not certain whether people need variety or consistency in workload).

A natural response to underload is to increase task demands by introducing additional activities. However, these tasks should be related to the primary task, particularly in safety-critical tasks and environments. The key is to maintain a cognitive connection. For example, in semi-automated driving, providing tasks that enhance situational awareness (such as, say, a concurrent verbal commentary) can keep the driver engaged. Rather than allowing total passivity, we can encourage actions that maintain a certain level of cognitive engagement while still benefiting from automation's support.

"While full automation is still a distant goal, the intermediate stages, where operators go from minimal engagement to needing to take sudden control, are fraught with risks."

A more radical idea to tackle underload is to rethink how we introduce automation. At the moment, automation is advancing in stages. While full automation (which the automotive industry refers to as 'Level 5') is still a distant goal, the intermediate stages, where operators go from minimal engagement to needing to take sudden control, are fraught with risks.

Instead, we might consider waiting until full automation is achievable, avoiding intermediate phases altogether. While this is a more extreme suggestion, until technology is capable of fully autonomous operation, the issues associated with underload will continue to pose safety challenges.

CONCLUSION

Mental underload is a classic problem in Human Factors research and real work. Addressing it requires evidence-based system design and behavioural interventions. As automation continues to evolve, it's essential to maintain a balance that keeps people meaningfully engaged enough, without overloading them. Ultimately, tackling underload is about keeping people in the loop so long as they have to be able to take control.

Watch Professor Mark Young's webinar Mental underload...what it is and what it isn`t, hosted by EUROCONTROL on 25 June 2024 at https://skybrary.aero/webinars/mental-underloadwhat-it-and-what-it-isnt.

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Steven Shorrock
Editor in Chief of *HindSight*

HUMAN PERFORMANCE IN THE SPOTLIGHT: MENTAL PRACTICE

In this series, human performance issues are addressed by leading researchers and practitioners in the field. Steven Shorrock gives some insights on the concept of mental practice.

WHAT IS MENTAL PRACTICE?

"Mental practice is the deliberate rehearsal of a task in imagination without large physical movements."

Air traffic controllers, pilots, and astronauts all rehearse complex procedures in their minds as part of learning and preparation. This is called 'mental practice' and has a long history in other sectors, from sport to surgery. Mental practice is the deliberate rehearsal of a task in imagination without large physical movements. It is something that we do spontaneously in everyday life, especially when learning a new skill, but is done in a more structured and deliberate way by some professionals.

HOW DOES MENTAL PRACTICE WORK?

Much research suggests that practising a task in imagination can improve motor and cognitive skills. Imagery plays both a motivational and a cognitive role in influencing behaviour. At a motivational level, imagery helps to manage arousal and affect, and helps with motivation for specific goals and activities. At a cognitive level, imagery helps to represent general strategies and practise specific skills.

There is now much evidence from cognitive psychology, neuroscience, and performance research for the 'functional equivalence' of mental and physical practice, particularly in skill learning. This means that engaging in mental imagery during mental rehearsal can elicit similar cognitive and physiological responses to those involved in actually performing the task. The brain treats imagery and physical practice in similar ways.

"The brain treats imagery and physical practice in similar ways."

This equivalence stems from the brain's tendency to process imagined actions in a manner analogous to real actions. Research in neuroscience, using techniques like functional magnetic resonance imaging (fMRI) and electroencephalogram (EEG), has consistently shown that mental imagery and physical practice activate overlapping brain regions. For example, studies show significant activation in the occipital lobe, which processes visual information, both when individuals imagine visual scenes and when they see the scenes. This suggests that the brain processes the imagined action in a way that closely resembles the processing of the actual action.

HOW DOES MENTAL PRACTICE COMPARE WITH PHYSICAL PRACTICE?

A common research finding is that mental practice is more effective than no practice but less effective than physical practice. However, the most effective approach is usually a combination of mental and physical practice.

  

WHAT KINDS OF TASKS BENEFIT FROM MENTAL PRACTICE?

Mental practice is particularly effective for relatively complex tasks that rely heavily on mental activities such as problem-solving, decision-making, planning, sequencing, spatial reasoning and visualisation, anticipation, and coordination. These mental activities are fundamental to the tasks of air traffic controllers and pilots. As well as the type of task or skill, mental practice is affected by the type of instructions, and the individual's skill level, imagery ability, and motivation.

WHY SHOULD AIR TRAFFIC CONTROLLERS AND PILOTS DO MENTAL PRACTICE?

Mental practice can enhance skill learning in tasks with a strong cognitive component, which are typical of controlling and flying. Air traffic controllers highlight the importance of their 'mental picture' of the airspace and traffic. Research suggests that some controllers use mental imagery to create and maintain this picture.

Controllers could integrate mental practice into training to rehearse scenarios and skills, such as conflict scenarios, communication and coordination, and procedures for using equipment. Mental practice could also help controllers improve their ability to recover from equipment failure.

Mental practice can be incorporated into pilot training to rehearse procedures, improve decision-making in emergency situations, and enhance spatial awareness during flight. This is often termed 'chair flying' and has been the subject of research. Mental practice could be particularly beneficial in the early stages of learning.

Mental practice has been found to be effective for training in other professions such as surgery, but has been researched most extensively in the context of sport.

WHO WOULD BENEFIT MOST FROM MENTAL PRACTICE?

Individuals with pre-existing strengths in generating, maintaining, and manipulating mental images seem to get most benefit from mental practice. Research has found that this includes controllers and pilots. Within the controller and pilot population, and in other professions such as surgery and sport, individuals with stronger imagery abilities would likely benefit most. Imagery abilities include vividness, controllability, and accuracy of reference.

Vividness refers to the clarity of the images evoked in the mind. Individuals with high vividness experience images that are more lifelike and detailed. They are also more likely to report using imagery in their daily lives. Controllability refers to the ease with which an individual can manipulate mental images. This encompasses the ability to generate, maintain, inspect, and transform images at will. Individuals with high controllability can readily manipulate their mental image of a scene, situation or scenario to explore different possibilities. Accuracy of reference refers to the fidelity of the image's content in relation to the real world, encompassing dimensions and magnitude of visual images and movements. Those with high accuracy of reference would have a mental picture that accurately reflects relative distances, directions and trajectories, for instance.

> "Mental practice can be effectively incorporated into training programmes for professions that rely heavily on cognitive skills and spatial reasoning."

WHO WOULD BENEFIT MOST FROM MENTAL PRACTICE?

Mental practice can be effectively incorporated into training programmes for professions that rely heavily on cognitive skills and spatial reasoning, via the following activities:

- **Identify cognitive components:** Begin by identifying the specific cognitive components of the skills being trained. For example, in air traffic control, this could include spatial reasoning, decision-making under pressure, communication protocols, and methods of use for equipment.
- **Develop realistic scenarios:** Create realistic training scenarios that require trainees to engage these cognitive skills. The scenarios should simulate the challenges and complexities that trainees would encounter in real-world situations.
- **Guide imagery techniques:** Provide clear instructions on how to employ mental imagery during practice. This could include techniques for image generation, maintenance, inspection, and transformation. Encourage trainees to practise with both eyes open and closed to determine what works best for them.
- **Incorporate into existing programmes:** Integrate mental practice as a complementary component within existing training programmes. This could involve dedicating specific sessions to mental practice or incorporating short periods of mental rehearsal before, during, or after physical practice sessions.
- **Target early stages of learning:** Emphasise the use of mental practice during the early stages of learning when trainees are still developing their understanding of the task and forming cognitive schemas.
- **Tailor to individual needs:** Provide opportunities for trainees to assess and enhance their imagery skills through targeted exercises. Consider individual preferences.
- **Address potential interference:** Educate trainees on the potential for interference effects between imagery and perception. This could involve discussing situations where relying too heavily on imagery might hinder their ability to perceive and respond to actual information.
- **Combine with physical practice:** Emphasise that mental practice is most effective when combined with physical practice. Use mental practice to supplement and reinforce the learning gained through hands-on experience.

FURTHER READING

Shorrock, S. T., & Isaac, A. (2010). Mental imagery in air traffic control. International Journal of Aviation Psychology, 20 (4), 309-324. https://bit.ly/3Y1GcQU

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PEOPLE IN CONTROL

A CONVERSATION WITH CAPTAIN JAMES BURNELL

Aviation is heavily reliant on procedures, but procedures can never replace human adaptivity in all situations. In this interview, *HindSight* editor Steven Shorrock talks to Captain James Burnell, British Airlines Pilot Association safety representative, about how people stay in the loop and in control. James argues for the need to learn by doing and learn through informal networks in informal spaces, warning that these are under threat in an ever more tightly controlled environment.

- **Possibility space and patterns:** The 'possibility space' is where operational decisions are made based on a variety of responses to different demands and contexts. Patterns – learned constellations of responses in this possibility space – play a critical role in decision-making.
- **Learning through practice:** Most decision-making involves tacit pattern-based recognition learned by doing. Rigid training structures that don't allow for real-world problem-solving are problematic. Simulation training does not fill all of these gaps.
- **Leadership in learning:** Effective leadership means encouraging first officers and other professionals to explore their possibility space in order to learn how to create possibilities. People need the authority, competency and confidence to be able to practice.
- **Limits of formal systems:** Formal safety systems can be overly restrictive, limiting the flow of operational knowledge. Crew rooms, informal networks, and narrative-driven, experience-sharing approaches to learning are needed.

Among front line operational professionals of all kinds, there are those who have a special interest in how to improve performance. Some of these professionals spend much time studying the various disciplines involved – human factors, psychology, complexity science, systems engineering, and so on. I have spoken to many in aviation, shipping, healthcare, emergency services, and other sectors. Some can be found in the back issues of *HindSight* magazine. One person I have spoken to many times over the years is James Burnell, a Scottish airline captain, union rep, and student of complexity and system performance. I met James to talk about some of his perspectives on *People in Control: Staying in the Loop*. In his Edinburgh home, close to his base airport, we discussed theory and practice with implications for professionals and organisations.

JOURNEY TO CAPTAINCY

Aviation infused James' childhood. Growing up in Scotland, his father was an airline pilot with British Airways, in the Highland and Islands division. Initially attracted to aerospace engineering, James started a degree at Glasgow University, but he got the chance to fly during that time, and his passion for flying was ignited.

While looking for work as a pilot, James worked for various airlines writing operations manuals. But he realised that he was drawn more to the practical aspect of flying than office-based work. *"I enjoyed the problem solving – the novel solution generation – more than routine and rigid structures."* He started flying as first officer (FO) in the late 1990s on Shorts 360s and SAAB 340 in the Scottish Highlands and Islands, and later in Scotland. He has fond memories: *"It is probably the nicest job in flying, because you get to see this incredible scenery. My first sector on the Shorts 360 was a mail run from Glasgow to Stornaway. We took off at about five in the morning, with the sun coming up in the East as we headed out over Loch Lomond and across the hills. And I just thought…'I've made it. This is tremendous.'"*

The financial rewards were better elsewhere, though, and James moved on to bigger airlines. This was more controlled, but still with *"a nice amount of problem solving…you actually get to fly a plane"*. He eventually got seniority and ended up in Edinburgh, and earned a command rating on the Embraer 145 in 2005.

With just a handful of routes, mostly within the UK, the number and timing of sectors were quite different to what he and other pilots experience today.

The next transition was to a new airline with direct entry command, and to the Airbus. To become comfortable with this aircraft took more than a year, which was longer than previous aircraft types due to the very different operating philosophy. From initially flying just UK-based routes, more routes were added over the years *"and it became more and more punishing from there"*, he noted, hinting at the challenges of flying now compared to 20 years ago.

THE POSSIBILITY SPACE AND PATTERNS

This variety of operational experience leads us to the topic of variety more generally in operations. There are interesting differences between bases in terms of size and culture that affect operations and approaches to safety. Some bases are very procedurally focused, while others are more adaptive. James has observed that in smaller regional bases, first officers have a lot of responses to various situations. *"They can hand fly. They can use the manual thrust. They have lots of different ways of controlling the aircraft."* At the larger bases, things are much more rigid. *"They stick to the standard operating procedures because they don't get that freedom to try things."* Exploring the reasons for this, James said that the captains and the first officers would rarely meet each other more than once a year in the large bases. *"They don't get that comfort with each other to try to explore the possibility space."*

The concept of the 'possibility space' and the related concept of 'patterns' shaped the next part of our conversation. James' thoughts about people in control and staying in the loop are surprisingly theoretical for a captain interested in practical problem solving. This is because James has been keeping up with theory in safety and complexity theory over the years, and applying that within the British Airline Pilots' Association (BALPA), in his role as a safety representative.

The possibility space is just that – the possibilities that exist in a given situation. This depends on all sorts of things, and the many contexts and constraints – regulatory, procedural, technological, organisational, temporal, environmental – and the expertise and networks available. Patterns, meanwhile, exist both in our environments as 'stable-enough states of the world' that our mind and bodies are aware of (not necessarily consciously), and within our minds and bodies as corresponding triggered patterns, which have previously developed during similar experiences. These patterned responses are rarely consciously available to us in the form of logical thought, although our minds make us think so after the fact. Patterns, James argues, are the basis for most operational decision-making. Existing patterns can be combined with logical thought to explore different possibilities, generating novel ways of responding to very contextually-specific problems.

> "In very complex situations, especially crisis situations, you need a very quick response. And that's what these patterns do. They give you a heuristic or a rule of thumb on how to act."

In the decision-making literature, this relates both to 'recognition-primed decision-making', popularised by Gary Klein in his research and book *Sources of Power – How People Make Decisions* and the predictive processing models of human cognition developed by Karl Friston, Andy Clark and Anil Seth. *"Most decisions involve tacit pattern-based recognition from actually doing the job or other outside experiences,"* said James. *"A lot of it is autonomic,"* not conscious or thought-through. *"In very complex situations, especially crisis situations, you need a very quick response. And that's what these patterns do. They give you a heuristic or a rule of thumb on how to act."* Patterns mean that we don't have to waste energy on working out solutions from first principles which would very quickly generate information overload.

An obvious heuristic for staying in control that all pilots know is 'aviate, navigate, communicate'. *"When you've stabilised the situation enough, you can start making more sense of what's going on."* There can be even simpler if-then rules, James noted: *"if something bad happens in the cockpit, then turn the seatbelt sign on because it gets the cabin ready."*

LEARNING PATTERNS

An important way of learning patterns is by doing – by trying things in practice. Again, what is critical here, James said, is creating potentials and possibilities: *"You need as many responses as things that happen."* Due to the increasingly complex nature of our system, things that go wrong are very likely to be unknowable or unimaginable in advance. This means that we cannot and should not specify everything people need to know in advance. Learning needs to be delivered by the exploration of the possibility space.

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So, some of the focus needs to be on creating possibilities in advance of need. James gave the following example: *"If you have a technical issue that precludes the use of the auto-thrust, which is a function of the aircraft that automatically controls speed, then having the ability to manually take on that function becomes vital. It may be that function interacts with another function you have learned and combining these further extends the possible responses that a pilot has to meet the demands* *of any given situation."* This means generating potentials to meet needs that are unknown, unpredictable, even unimaginable. *"You're preparing for a need that you can't possibly specify,"* he said. *"So, you have to continually generate potentials even though you may never use them."*

"A lot of the new pilots come in thinking 'this is so controlled that I can just follow the process every time'. That doesn't work because context changes."

This highlights problems with very rigid training structures which encourage thinking of *"the next right thing to do in a fixed sequence"*, as if flying an aircraft was like operating a production line. *"A lot of the new pilots come in thinking 'this is so controlled that I can just follow the process every time'. That doesn't work because context changes."* And all of this means that practice in the real world, with all its messiness and unpredictability, is essential. By avoiding practice in the real world, the risk shifts to being unprepared for surprises.

As mentioned earlier, learning by doing also means doing the basics. Regulators and airlines have recognised the need to practise visual approaches, auto-thrust off, and manual flying skills generally, but many airlines only allow this in the simulator. A question for many is whether simulation practice of, say, flying with a single engine with no auto-thrust, will translate to real life. Can you still do it manually in operations?

LEADERSHIP FOR LEARNING

"In learning patterns, people need the authority, competency and confidence to be able to practise in ways that work for them. As an airline captain, I would say, 'this is my intent, can you make that happen?' And I would let that first officer make it happen as they saw fit."

In learning patterns, people need the authority, competency and confidence to be able to practise in ways that work for them. Those in leadership positions have a particular role here. *"As an airline captain, I would say, 'this is my intent, can you make that happen?' And I would let that first officer make it happen as they saw fit."* Executing what James calls a *"generative learning process"* of building potential responses to demands and conditions. The idea is that operational people make contextually appropriate decisions, but in the direction that's coherent with more senior decisions. The same is true in a team and organisation more generally: *"maintain coherence of direction and distribute sensemaking and decision-making down through the individual layers".*

James gave the example of an instrument landing system (ILS), where the aircraft would need to capture the glideslope at the right speed and the right height, or this would create problems. Heavy airliners have lots of energy, so getting the aircraft to slow down and go down can be a challenge, he noted. *"I would make sure that the FO is in the loop, and I would watch to make sure that the aeroplane is always within my control should it start to deviate. But I wouldn't necessarily take over if things started to go awry. I could throw in ideas, but they're never going to become captains if I do everything for them."*

The emphasis, again, is on the need to explore the possibility space. James recalled situations where it's been windy, and the aircraft has been upset on the approach. *"The FO has tried to hand it to me to land: 'I can't do this, you take it.' I say that if you don't feel that you can land, you can go around. Of course, I can take it, and I can go around and I can land it, but they're not going to learn anything by throwing their hands up and asking me to do it."* This approach provides an important learning opportunity combined with a confidence gain. *"When they come out the other side from where they thought they couldn't do it, wow, they're a different person. 'I can do this. I can learn, I can change."* James gave another example where police have come onboard to talk to passengers. "*I wouldn't necessarily get involved in that because the cabin manager is an experienced professional. They understand the situation and they're dealing with the passengers already. I am, of course, there for support or direction, or the company line."* His point is that to be in control, people need to learn through experience of how to deal with the context that they're in.

This approach to leadership and learning is not necessarily common, particularly outside of the aircraft. James observed that among ground staff there can be a lack of decision-making authority. This can result in almost farcical referral to superiors for decisions that should be taken by competent and experienced professionals in the situation. Processes and procedures can be a useful scaffold, he noted, but we all need space to adapt to cope with the complex, changing environment.

LEARNING FROM OTHERS' EXPERIENCES

Of course, not everything has to be learned first-hand. Aviation safety is built on generations of experience. This is communicated through patterns. In the social case, social scientists might call them 'assemblages'. *"Pilots have generations of knowledge in these patterns because so much processing of decision-making has been done before. Learning is a social process, and we can pass on these patterns for learning those."*

"Pilots have generations of knowledge in these patterns because so much processing of decision-making has been done before. Learning is a social process, and we can pass on these patterns for learning those."

So, at the beginning of training, *"you're preloaded with enough patterns to get you started."* This continues throughout training. *"When I'm sitting in a simulator and I have an experienced training captain talking to me and things haven't gone quite as well as they could, the training captain may well come and say, 'look, try this thing that we've seen from other people as it works well'."* Those training captains are in a unique position of having observed and listened to hundreds of other captains and are then able to transmit vital cultural knowledge.

"Training captains are in a unique position of having observed and listened to hundreds of other captains and are then able to transmit vital cultural knowledge."

Most pilots aren't in that position, though. So, there is a need for airlines and other organisations to allow information flows. For pilots, crew rooms were always a key part of this learning. *"Now a lot of the airlines have got rid of the crew rooms"*, James said. *"You just report straight to the aircraft. I notice a difference in how these patterns are passed on and the impact on the way people operate."* Many of his colleagues have said that the loss of crew rooms has affected their operational communication with other operational staff. For safety management professionals too, time sat in crew room can be the most valuable experience possible, I have experienced this in simulators, and just hanging out with controllers. This is where informal accounts of experiences can be heard. *"There's no high energy barrier, such as forms to fill in. You can say, 'look, I did this, and this happened'."* That, for James, is 'being in the loop', and radically different to the decontextualised data of reporting systems.

There are a few other opportunities for informal, face to face, verbal exchanges between certain operational staff, and with safety staff. While cabin crew spend much time together, like consultants in a hospital, captains don't necessarily meet each other often: *"You never fly with another captain."* So how do you get those informational flows going? Interestingly, James has observed that captains can also learn from first officers who have picked up patterns from other captains. But he believes that captains especially have an unmet need to sit down in an informal setting to talk about experience and mistakes. This kind of conversation does not happen in the same way with first officers, James said, and if it does, *"it's heavily filtered"*. From a company perspective, a lesson here is that people need opportunities to listen and pass on information to others about their experiences.

THE LIMITS OF FORMAL SAFETY LEARNING SYSTEMS

There are, of course, formalised means to share experience. And in aviation, it is tempting to think that all information should pass through these highly managed conduits. James noted that *"I think one of the problems we face in the airline industry is that we are very focused on explicit information."* So, what's the problem? Why can't company and other industry reporting and learning systems meet this need, for example? One constraint is that legacy reporting systems – with their forms and taxonomies – necessarily restrict the type of information gathered. What can be inputted is predetermined based on capabilities and limitations of the technical systems involved, their designers, and feedback from experience. That restriction of information flow also restricts the ability of the organisation to respond. Codification and quantitative analysis of free text or interview data – while useful at scale to find trends – deconstruct narratives and removes meaning. Furthermore, there is always a lag in feedback to staff, which can be weeks, months or even years.

"People need opportunities to listen and pass on information to others about their experiences."

There are industry-wide voluntary reporting systems that allow for more free narrative and faster feedback. These include, for instance, the Confidential Human Factors Incident Reporting Programme (CHIRP) in the UK. A constraint here is what is chosen to be fed back, by whom, and how (see Waites and Burnell, 2023). It may be that frequently-reported issues are fed back while others are not. This is relevant, but *"what you probably want to do is just get as many potentials as possible for people to consider"*, James argued.

Practices that work well are sometimes turned into procedures. But this isn't always possible or even desirable. This brings us to the difficulty of formalising or manualising patterns. *"As soon as you write it down, you've almost corrupted it because you've fixed it independent of context. You've lost that ability for it to adapt and evolve."* James compares this with storytelling of fairytales through the generations in the oral tradition; the lessons for us are lost. *"As soon as we wrote these stories down, we started to lose the context of why we were telling them."*

WHAT CAN USEFULLY BE DONE?

So, what can usefully be done? Allowing human interactions to exist closer to the way that we evolved is a great start. Social networks have always transferred information in efficient ways to optimise community responsiveness.

An obvious starting point is not to remove crew rooms, or reintroduce them. Crew rooms are not wasted spaces, they can be valuable learning spaces for casual verbal exchanges. For people to discuss operational information, there has to be a low friction way to do so. Crew rooms are also an important space for low-key social support, akin to coffee rooms and water coolers. An organisational desire to systemise everything and reduce perceived 'waste' works against these important ideals.

Another idea is a buddy system. James proposed that new joiners to any base or first officers approaching command would get allocated a buddy or mentor whom they could speak to. The buddy would change from time to time. Via this approach, new joiners would get added to informal networks in the background and reduce the degrees of separation between operational groups. These informal networks provide the information flows needed to work around formal constraints. James noted that companies that did well during COVID managed to adapt and keep operating largely due to the quality of their informal networks. For doctors, informal networks emerged as WhatsApp groups, which also exist for pilots. These can provide a means to share dynamic information on developing situations and novel solutions.

Despite the limitations to documenting experience, there are ways to collect short narratives. James suggests documenting people's accounts of how they work, and why they're responding in particular ways. *"Collect a hundred stories for inexperienced pilots to read on, say, go-arounds that didn't go as expected. Then build patterns or understandings through these small narrative structures. 'I did this, and this is what happened.'"* Airlines, James said, do this for big incidents and can be very good at it, but not for 'ordinary work'. He suggested a book of just a few lines on each topic, as many small stories on a topic are preferable to one long one. He also suggested to bias it towards failure rather than success. *"Because you're going to remember failure. People learn a lot more from failure."* Interestingly, many old fairy stories and folk tales concern failure. In learning from our own experience, our current patterns are only adjusted if we perceive them as wrong, the patterns didn't 'do the trick' – they didn't 'satisfice'. In evolutionary terms it's better to not fail than to optimise, so our brains seek ways to not fail.

Narratives can be examined via different methods for themes and patterns that show how groups of people see and use them in the world. Captured narratives can be assessed as optimal or not, allowing us to move them in a preferable direction or to be passed to other groups if they apply. *"This is much more powerful than any compliance structures,"* James argued, *"and much more ethical."*

"Regulations should encourage continuous learning, staying contextually responsive and being prepared to be surprised."

So where do regulators come into this? *"My big thing is that there have to be generative structures at each different level"*, said James. *"So rather than improving the regulation to create the perfect organisation, we should improve the regulation to help generate organisations that evolve towards greater evolvability."* In other words, regulations should encourage continuous learning, staying contextually responsive and being prepared to be surprised (See Woods, 2023). This is very different to compliance or 'best practice', because not everything can be specified and there is no best practice in complex, volatile situations – only practice that is contextually appropriate. *"So actually, the regulator has a huge part to play, but it's not the part I think they're necessarily playing at the moment."*

MOVING FORWARD

This conversation with James has been one of many, but one that could be useful to reflect on. The discussion raised many questions worthy of reflection by professions and organisations. For instance:

- How can we foster a greater variety of responses to potential problems, even if those problems are currently unimaginable?
- How can we leverage informal networks to facilitate knowledge sharing and learning?
- How can we ensure that decision-making is contextually appropriate and adaptable to changing circumstances?
- What are the limitations of formal safety management systems and how can they be supplemented by more informal approaches?
- How does the increasing reliance on technology affect the development and maintenance of operational skills?
- What specific roles can leaders play in fostering a culture of learning and experimentation?
- How can regulators promote a more adaptive and learning-oriented approach to safety regulation?
- How does culture influence the way people approach problem-solving and learning?

James is integrating these ideas into his work with pilots via BALPA, using distributed sensemaking and decision-making, and gaining members' stories to understand what pilots are thinking. James' emphasis on adaptability, learning by doing, and narrative-driven learning challenges rigid, procedural adherence and overly formalised safety management systems. In aviation and beyond, he highlights the need to create environments where operational professionals can continuously learn, adapt, and evolve to meet the ever-changing demands of their roles. Despite the *"punishing"* nature of piloting for some today, he remains optimistic about the possibility space. *"It is fascinating when you get into the 'how and why' of managing systems for safety. There's a long way we can go, but there's lots of stuff out there. I think very positively about where it could go."*

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CAPTAIN JAMES BURNELL is a pilot and safety rep based in Edinburgh with the UK airline easyJet. He supports the British Airline Pilots' Association in creating and promoting safety theory. James has a strong interest in generalist learning, cutting across many scientific fields with the aim of improving the safe management of humanistic systems.
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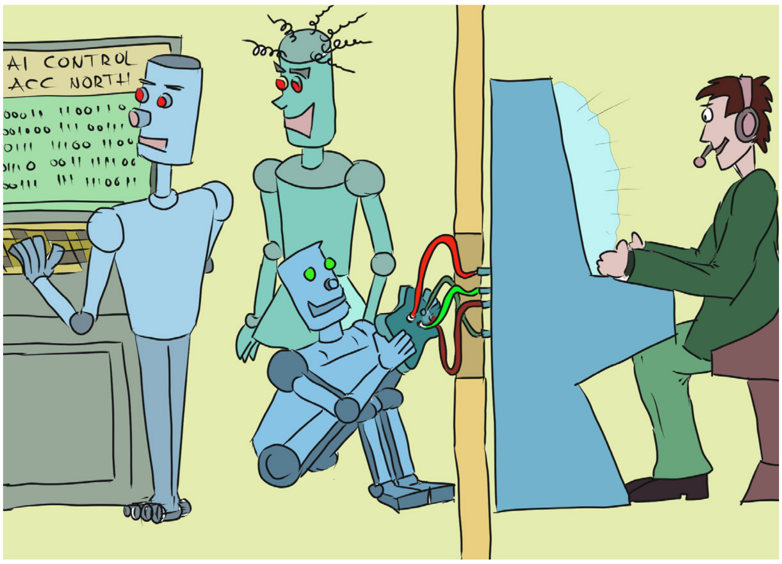
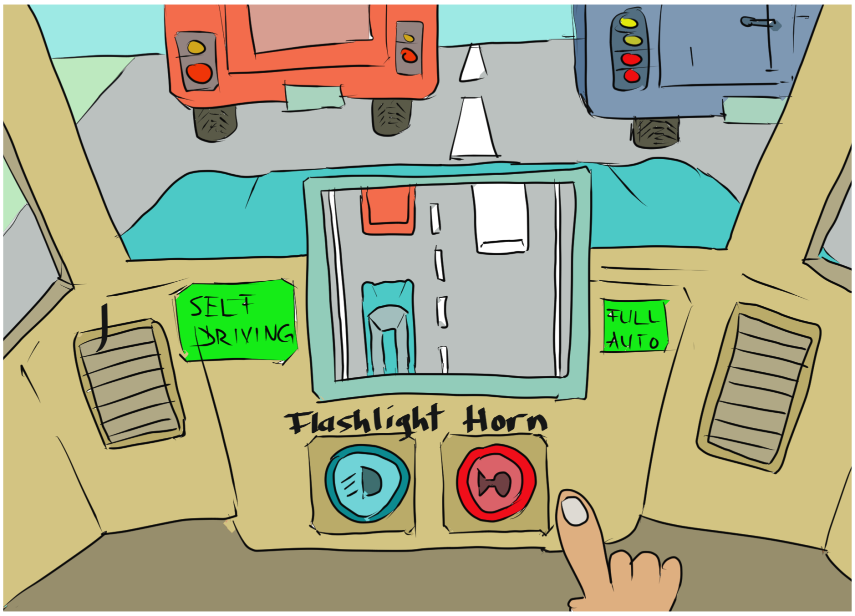
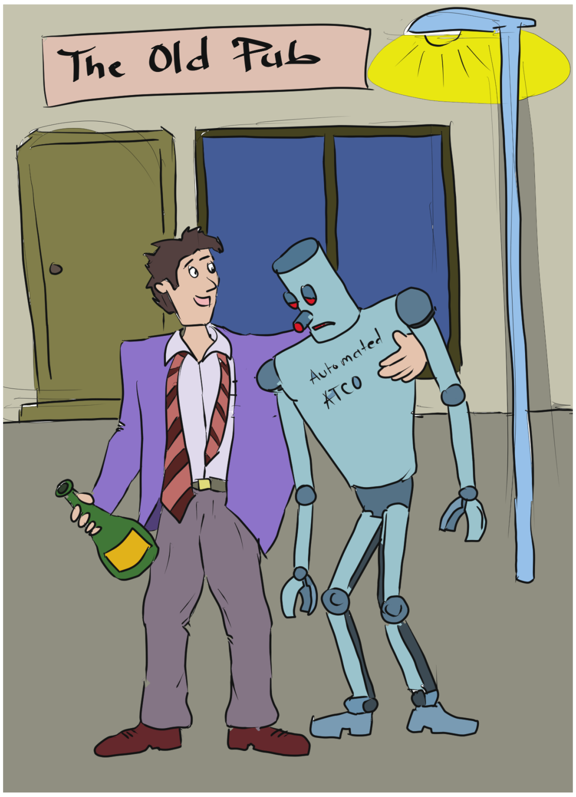


"This is brilliant, George! This way, the humans feel in the loop, we can work undisturbed, and they feel like they have something to do!"

"I told you that was the last time I will hear the 'It was a data entry error' excuse!"

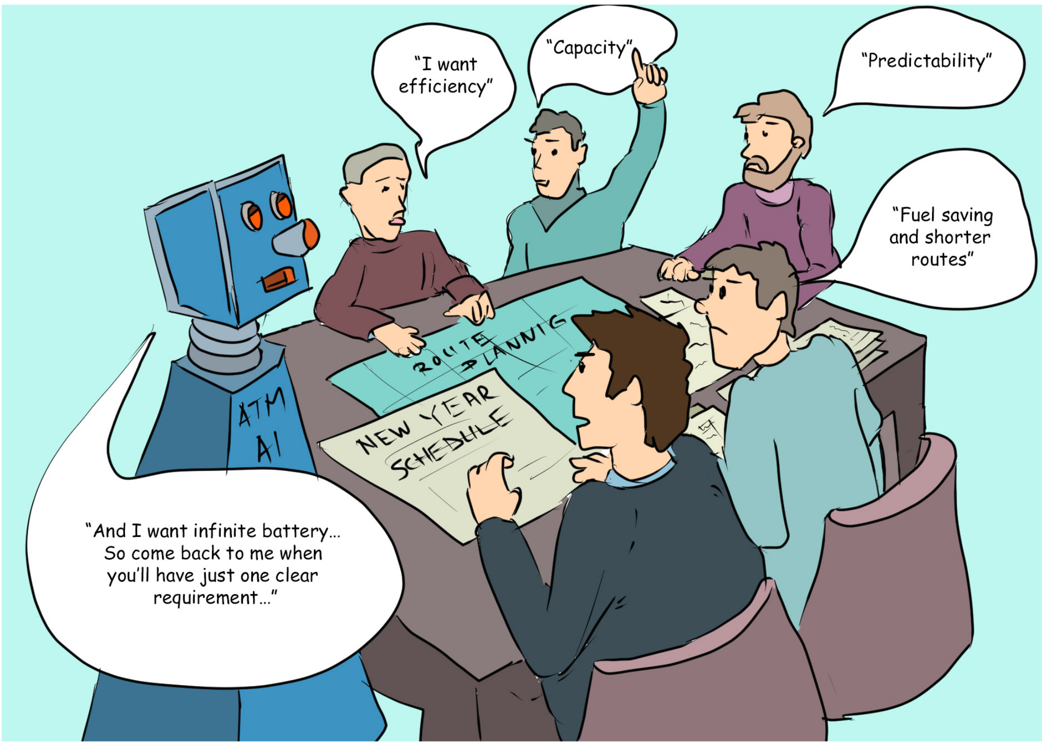


"After extensive research and testing, we found two essential controls that cannot be automated and require direct human input."



"I told you that happy hour does wonders for the team spirit. But I didn't expect that a can of WD40 would loosen you up that fast..."

"Hello chief, TH002 is calling sick.
It's got a nasty virus and is overheating."
"Try a patch and reboot. If that doesn't work, call in TH003."



PEOPLE IN CONTROL: STAYING IN THE LOOP
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 people in control: staying in the loop.

STRESS AND FATIGUE MANAGEMENT [HUM-SFM]

Based on Commission Implementing Regulation (EU) 2017/373 and ICAO annex 11 EUROCONTROL provides a safety-related course on fatigue and stress management. The course will enable participants through practice and discussions to grasp the key factors producing stress and fatigue and to evaluate and recognise impacts and develop coping strategies.

PREREQUISITES
Participants should have a basic knowledge on fatigue and stress and impact on human performance. This can be obtained by following the HUM-FAT-MGT and HUM-STRESS e-learning modules.

OBJECTIVES
To provide tools and support at both individual and organisational levels for managing stress and fatigue in operations. The course will provide participants with practical tools and knowledge to start a management plan (both at prescriptive and FRMS level).

AUDIENCE
Managers and professionals that need to understand how to manage stress and fatigue in ATM.

HUMAN FACTORS FOR ATM SAFETY ACTORS [HUM-HFA]

Human factors (HF) is a discipline looking at all aspects of the human being at work. Thus, understanding HF in safety activities is crucial. This course covers the fundamentals of HF and is designed for a wide audience. The course focuses on understanding the strengths of the human being in order to intervene in the working environment to capitalise on human flexibility, adaptability and good judgement.

OBJECTIVES
After completing the course, participants will have an understanding of safety issues from a human factors perspective, which encompasses individual factors, social and organisational factors, the HMI and working environment factors. Participants will be able to recognise and emphasise the strengths of the human being - such as flexibility, adaptability and learning skills - thereby enlarging the scope of HF analysis beyond human errors and incident investigation. Additionally, participants will have an understanding of the central contribution of the human factor to any safety activity.

The large number of theoretical training (over 20 hours) on HF topics and the range of these topics make the course compliant to the HF requirements of EU regulations 965/2012, 1321/2014, 2015/340 as well as consistent with the ICAO documents 7192 in terms of HF (Training Manual).

AUDIENCE
This course is designed for staff having any safety role and responsibility in an ATM system, and other interested persons with a good understanding of operational matters.

TRM FACILITATOR
[HUM-TRM-F]

Team Resource Management (TRM) focuses on operational human performance and teamwork in ATM operations. It explores the gap between "Work as Imagined" and "Work as Done" in human factors terms. When implemented effectively, TRM focuses on things that go well during daily ATM operations and facilitates ways to replicate this success. It encourages the exchange and understanding of operational pitfalls and strengthens the human safety net.

Personnel attending this course will be trained to use and adapt the EUROCONTROL prototype training material so that they are able to deliver TRM sessions for air traffic controllers.

A high level of English language proficiency is needed as participants can expect to facilitate a group discussion and to co-facilitate a half-day TRM session.

IMPORTANT NOTE

EU Commission Regulation 2015/340 states that one of the Acceptable Means of Compliance (AMC) for meeting the human factors ATC Refresher Training requirements (as part of Continuation Training) is to train air traffic controllers in team resource management. EUROCONTROL's well established TRM concept and prototype training material may be used by ANSPs to implement this AMC and consequently meet the regulatory requirement.

PREREQUISITES

A sound theoretical background of the TRM initiative is needed as this course focuses on practical TRM aspects. Participants are therefore required to have either completed the TRM in ATM course, Introduction to TRM course or Team Resource Management: The basics course.

OBJECTIVES

By the end of the course, participants will be able to:

- Use facilitation techniques to deliver TRM subject material
- Customise the existing prototype TRM training materials

AUDIENCE

This course is designed for personnel who wish to become TRM facilitators. It is primarily aimed at air traffic controllers. However ATSEP and AIM personnel will also benefit from this course.

OTHER COURSES AND WEBINARS:

- Systems Thinking for Safety [HUM-SYS]
- Design of ATC Simulation Exercises and Courses [HUM-SIM]
- Theoretical Training Instructor Skills [HUM-TTI]

Search https://learningzone.eurocontrol.int

WEBINARS ON DEMAND

Catch up on the latest EUROCONTROL human performance and safety webinars on demand at https://skybrary.aero/webinars. Below is a summary of the webinars of 2024.

SO WHAT DO PEOPLE ACTUALLY DO?
DR. IMMANUEL BARSHI

It is often said that to err is human. It's true that failures can be traced to human limitation, but what's more important is that all successes, all safe operations are the result of human capabilities. This talk highlights the resilience people bring to aviation operations and discusses ways to change the common narrative that people are the creators of safety rather than only the source of error and failure.

DR. IMMANUEL BARSHI is a Senior Principal Investigator in the Human Systems Integration Division at NASA Ames Research Center. His current research addresses cognitive issues involved in the skilled performance of astronauts and pilots, as well as mission controllers and air traffic controllers, their ability to manage challenging situations, and their vulnerability to error. Dr. Barshi holds PhDs in Linguistics and in Cognitive Psychology.

https://skybrary.aero/webinars/so-what-do-people-actually-do

SUPPORTING HUMAN-AI TEAMING: TRANSPARENCY, EXPLAINABILITY, AND SITUATION AWARENESS
DR. MICA ENDSLEY

System autonomy and AI are being developed for a wide variety of applications where they will likely work in tandem with people, forming human-AI teams (HAT). Situation awareness (SA) of autonomous systems and AI has been established as critical for effective interaction and oversight of these systems. As AI capabilities grow, and more effective teaming behaviours are expected of AI systems, there will also be an increased need for shared SA between the human and AI teammates. Methods for supporting team SA within HAT are discussed in terms of team SA requirements, team SA mechanisms, team SA displays and team SA processes. A framework for understanding the types of information that needs to be shared within HAT is provided, including a focus on taskwork SA, agent SA, and teamwork SA. AI based on learning systems creates new challenges for the development of good SA and mental models. AI transparency and explainability are discussed in terms of their separate roles for supporting SA and mental models in HAT. The SA Oriented Design (SAOD) process is described as a systematic methodology for developing transparent AI displays for HAT and an example of its application to automated driving in a Tesla is provided. Situation awareness (SA) is critical for effective interaction with AI systems.

DR. MICA ENDSLEY is president of SA Technologies and a former Chief Scientist of the U.S. Air Force. She has also held the positions of Visiting Associate Professor at MIT in the Department of Aeronautics and Astronautics and Associate Professor of Industrial Engineering at Texas Tech University. Dr. Endsley is a recognised world leader in the design, development and evaluation of systems to support human situation awareness (SA) and decision-making, as well as methods for improving SA through training of individuals and teams.

A LIFE IN PICTURES: BRINGING BREAKTHROUGHS IN SAFETY PERFORMANCE
GRETCHEN HASKINS

This webinar series delves into the lives and careers of inspirational people who have made a significant difference to the safety and performance of safety-critical industries. Our second guest was Gretchen Haskins, who reflected on ten pictures to tell the story of her life. Hosted by Steven Shorrock.

GRETCHEN HASKINS is a board director for HeliOffshore Ltd. and the Flight Safety Foundation. Both organisations are dedicated to global aviation safety. She is an aviation industry leader in safety performance improvement and an internationally-recognised expert in human factors. Previous roles include CEO of HeliOffshore, and Group Director of Safety at the UK Civil Aviation Authority, Group Director of Safety at the UK air traffic company NATS.

https://skybrary.aero/webinars/life-pictures-gretchen-haskins-bringing-breakthroughs-safety-performance

MENTAL UNDERLOAD... WHAT IT IS AND WHAT IT ISN`T
PROF. MARK YOUNG

This webinar offered an insight into the concept of mental underload – what it is (as far as we are able to define it), what it isn't, how it compares to related concepts (such as boredom or vigilance), what causes it, how and why it affects performance, how to measure it (as far as we are able to), and how to guard against it. Transport case studies were given as examples of where underload has been implicated in accidents.

PROF. MARK YOUNG is a Professor of Human Factors in Transport within the Transportation Research Group at the University of Southampton. Mark has nearly 30 years of experience working in human factors across transport modes in both academia and industry. Before joining the University of Southampton in June 2023, Mark spent 11 years working as an Inspector at the Rail Accident Investigation Branch, applying his human factors expertise to the investigation of railway incidents and accidents. Mark has written over 70 peer-reviewed journal papers and five books.

https://skybrary.aero/webinars/mental-underloadwhat-it-and-what-it-isnt

A LIFE IN PICTURES: SAFETY AND LEADERSHIP
TONY LICU

This webinar series delves into the lives and careers of inspirational people who have made a significant difference to the safety and performance of safety-critical industries. The series kicked off with Tony Licu, who reflected on ten pictures to tell the story of his life. Hosted by Steven Shorrock.

TONY LICU has recently been appointed as the acting Head of the Network Manager Directorate Technology Division at EUROCONTORL. Prior to this, Tony has been the Head of Operational Safety, SQS and Integrated Risk Management Unit & the Head of Digital Transformation Office within Network Management Directorate of EUROCONTROL. He leads the support of safety management and human factors deployment programmes of EUROCONTROL as well as the digital transformation of the Network Manager

https://skybrary.aero/webinars/life-pictures-tony-licu-safety-leadership

USE OF OPERATIONAL BREAKS

This webinar aimed to provide a multi-perspective view on the use of operational breaks in the aviation domain. The five presenters gave insights derived from operational experience, empirical observations, analysis of neuropsychological implications, guidance on fatigue management, and behaviour change frameworks. The webinar provided useful information on prevailing practices, concerns, and good practices in relation to rest breaks in aviation. The webinar is also relevant to other high-tempo domains where breaks are critical for human performance and wellbeing. The webinar featured five short talks from different speakers, followed by a Q&A session.

- **Eric Carter** – Safety Analyst and former ATCO (FAA)
- **Marinella Leone** – Advanced Learning Team Leader (EUROCONTROL)
- **Adriana-Dana Schmitz** – Human Factors Expert (EUROCONTROL)
- **Antonio Licu** – Acting Head of the Network Manager Directorate Technology Division (EUROCONTROL)
- **Steven Shorrock** – Senior Team Leader – Human Factors (EUROCONTROL)

https://skybrary.aero/webinars/use-operational-breaks

FROM COMPLIANCE TO DILIGENCE: A MARITIME SAFETY PERSPECTIVE
DR ANTONIO DI LIETO

This webinar aimed to provide a general overview of maritime safety with a focus on how the legal concept of due diligence and academic principles on safety leadership can co-exist. A catastrophic accident which caused loss of nine lives, with criminal convictions of shipboard officers and the collapse of the port control tower, were used as a case study. In the event of a large-scale accident, in order to deal with the increasing level of scrutiny by the courts and by an increasingly intolerant public opinion, both management and operators at the sharp end must be able to demonstrate that they have done everything possible to prevent it, by shifting the emphasis from compliance to diligence.

DR ANTONIO DI LIETO is a former ship master and hydrographer who has been working with maritime simulations since 2011. He matured such experience in Australia, where he facilitated ship manoeuvring studies and marine pilot training. At present, he manages simulations studies carried out at CSMART, Carnival Corporation training centre in The Netherlands. He has been lucky enough to meet and work together with some of the experts who have spearheaded progress within the maritime industry over the last few decades and holds PhDs in Linguistics and in Cognitive Psychology.

https://skybrary.aero/webinars/compliance-diligence-maritime-safety-perspective

MANAGING SURPRISE IN HEALTHCARE
DR NEIL SPENCELEY

Dr Neil Spenceley, clinical director for paediatric intensive care and anaesthetics in Glasgow, explored the challenges of managing surprise in healthcare, particularly in complex and high-pressure environments such as intensive care. He argued that traditional patient safety approaches, often focused on preventing errors and imposing constraints to reduce variation, can reduce adaptability and create fear and anxiety. Dr Spenceley addressed issues such as second victim phenomenon, incivility, fear of admitting fault, and defensive medicine. He advocates a more holistic approach including understanding work-as-done, embracing 'muddling through', open communication, and learning from successes as well as failures. He emphasised the importance of understanding and appreciating the contributions of all healthcare professionals, including those in seemingly less prominent roles. He stressed the need to build a culture of psychological safety, where individuals feel empowered to speak up and share information, and learning from other industries.

DR NEIL SPENCELEY is the Director of Paediatric Intensive Care and Anaesthetics in Glasgow and the former Scottish Patient Safety Lead for Paediatrics. He is originally from The Highlands, trained in Edinburgh but soon defected West to start his somewhat bumpy career at Glasgow Children's. After living in Tauranga, Sydney and Vancouver he bizarrely returned to Glasgow where the weather is terrible but the people are positive and funny. His physiological interests include oxygen delivery, this and that but mostly that.

https://skybrary.aero/webinars/managing-surprise-healthcare

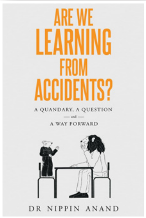
WORKING IN TEAMS IN AIR TRAFFIC CONTROL – A SHORT STORY OF HARRY HOUDINI AND THE WORLD AIR TRAFFIC CONTROLLERS LIVE IN
SEBASTIAN DAEUNERT

What does Harry Houdini, the once famous magician and Air Traffic Controllers have in common? It initially sounds incredible, comparing a sometimes dubious showman with well trained and experienced Air Traffic Controllers handling thousands of lives every day. But looking closer you will experience a driven magician bending rules and taking risks to satisfy an all-time increasing amount of expectations (on one hand). And then, there are ATCOs under pressure by traffic numbers, punctuality and stressful situations, coupled with the desire to deliver the best possible performance inside their closely linked team structure. Experience what the pressure of integration into a team really implies, the expectations a controller feels and wants to satisfy on his level of work.
This webinar is about Team Resource Management and shows some problems and solutions on how to handle everyday life in teamwork, in an occasionally humorous but mostly thoughtful way.

SEBASTIAN DAEUNERT is a retired ATCO and Safety Manager, Just Culture expert. Sebastian worked as an active TWR/APP controller for 15 years before getting into safety management and human factors. He was the Safety Manager of Frankfurt Tower until regular early retirement in 2021. He held several lectures at Human Factors Conferences in Brussels, Amsterdam, Madrid and Lisbon. He now works in the EUROCONTROL/ IFATCA prosecutor expert scheme and holds presentations at EUROCONTROL Just Culture Committee and the Safety Human Performance Sub-Group.

https://skybrary.aero/webinars/working-teams-air-traffic-control-short-story-harry-houdini-and-world-air-traffic

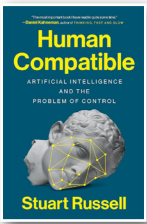
If you want to read more about some of the issues raised in *HindSight*, then these books might be of interest.



Are We Learning from Accidents? A Quandary, A Question and a Way Forward, by Nippin Anand (2024)

From the publisher: "Are we learning from accidents? Dr Nippin Anand's research into the Costa Concordia disaster and his interviews with Captain Schettino suggest not. The answer to the problem of learning lies not so much in designing fail-safe technologies and user-friendly systems as in questioning our fears, myths, beliefs, rituals, worldviews and imagination about risk and safety. When we recognise the mythical and non-rational nature of risk and safety beliefs, our focus will shift from counting and controlling hazards towards pathways that make us humble, curious, doubtful and conscious about the human 'being'. When we begin to accept that humans are fallible, we search for better ways to humanise the risks and relate to people. Through a lived journey of dissonance, disturbance, learning and change, this book offers an alternative pathway to wisdom in risk intelligence, and a method to tackle risks in an uncertain world."

"This brilliant book combines deeply personal insights and scholarly work, brought to bear on the important case of the Costa Concordia ship disaster. It's full of riveting stories about shipping, punctuated by cool-headed analyses of mistakes and learning in general. Nippin's labor of love will make everyone who reads the work a better, more interesting person."
(Lee Clarke, Emeritus Professor of Sociology, Rutgers University)



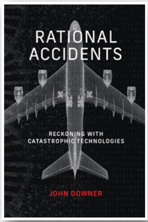
Human Compatible: AI and the Problem of Control by Stuart Russell (2020)

From the publisher: "Humans dream of super-intelligent machines. But what happens if we actually succeed?

Creating superior intelligence would be the biggest event in human history. Unfortunately, according to the world's pre-eminent AI expert, it could also be the last.

In this groundbreaking book, Stuart Russell sets out why he has come to consider his own discipline an existential threat to humanity, and how we can change course before it's too late. In brilliant and lucid prose, he explains how AI actually works and its enormous capacity to improve our lives - and why we must never lose control of machines more powerful than we are. Russell contends that we can avert the worst threats by reshaping the foundations of AI to guarantee that machines pursue our objectives, not theirs. Profound, urgent and visionary, Human Compatible is the one book everyone needs to read to understand a future that is coming sooner than we think."

"A thought-provoking and highly readable account of the past, present and future of AI . . . Russell deploys a bracing intellectual rigour . . . but a laconic style and dry humour keep his book accessible to the lay reader."
(The Financial Times)



Rational Accidents: Reckoning with Catastrophic Technologies by John Downer (2024)

From the publisher: "An unflinching look at the unique challenges posed by complex technologies we cannot afford to let fail—and why the remarkable achievements of civil aviation can help us understand those challenges.

Nuclear reactors, deep-sea drilling platforms, deterrence infrastructures—these are all complex and formidable technologies with the potential to fail catastrophically. In Rational Accidents, John Downer outlines a new perspective on technological failure, arguing that undetectable errors can lurk in even the most rigorous and "rational" assessments of these systems due to the inherent limits of engineering tests and models. Downer finds that it should be impossible, from an epistemological viewpoint, to achieve the near-perfect reliability that we require of our most safety-critical technologies. There is, however, one such technology that demonstrably appears to achieve these "impossible" reliabilities: jetliners.

Downer looks closely at civil aviation and how it has reckoned with the problem of failure. He finds that the way we conceive of jetliner reliability hides the real practices by which it is achieved. And he shows us why those practices are much less transferrable across technological domains than we are led to believe. Fully understanding why jetliners don't crash, he concludes, should lead us to doubt the safety of other "ultra-reliable" technologies.

A unique and sobering exploration of technological reliability from an STS perspective, Rational Accidents is essential reading for understanding why our most safety-critical technologies are even more dangerous than we believe."

"Rational Accidents is an important contribution to our understanding of safety and accidents. Downer finds the key to high reliability in jet aircraft less in keen engineering design, and more from engineers' and operators' deep learning from past accidents."
(Scott D. Sagan, Caroline S. G. Munro Memorial Professor of Political Science and Senior Fellow at the Freeman Spogli Institute for International Studies, Stanford University)

HindSight
Human and organisational factors in operations

The theme of *HindSight* 37 will be

MENTAL HEALTH IN AVIATION ... AND BEYOND

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 (ATM) and aviation, and beyond. The next issue of *HindSight* will look at the issue of mental health.

We welcome articles and short contributions by **Friday 2 May 2025**.

We welcome articles from aviation and other safety-critical sectors where lessons may be transferrable (e.g., rail transport, shipping, power generation, healthcare). We especially welcome articles written by or with operational staff, bearing in mind that operational staff are the primary readers. Articles may concern, for example:

- Fatigue and fatigue management
- Shiftwork, time zone changes, and circadian disruption
- Rest and sleep
- Burnout prevention and recovery
- Chronic stress
- Recovery from mental ill-health
- Neurodivergence and mental health
- Dealing with substance misuse and addiction
- Social isolation and loneliness
- Critical incidents and crisis management
- Training and simulator anxiety
- Addressing stigma
- Workload management
- Screening
- Licensing issues
- Organisational culture
- Support systems, coaching, and treatment
- Awareness and understanding

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 ATM and aviation more generally,
- be presented in 'light language' keeping in mind that most readers are operational staff, and
- be useful and practical.

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

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.

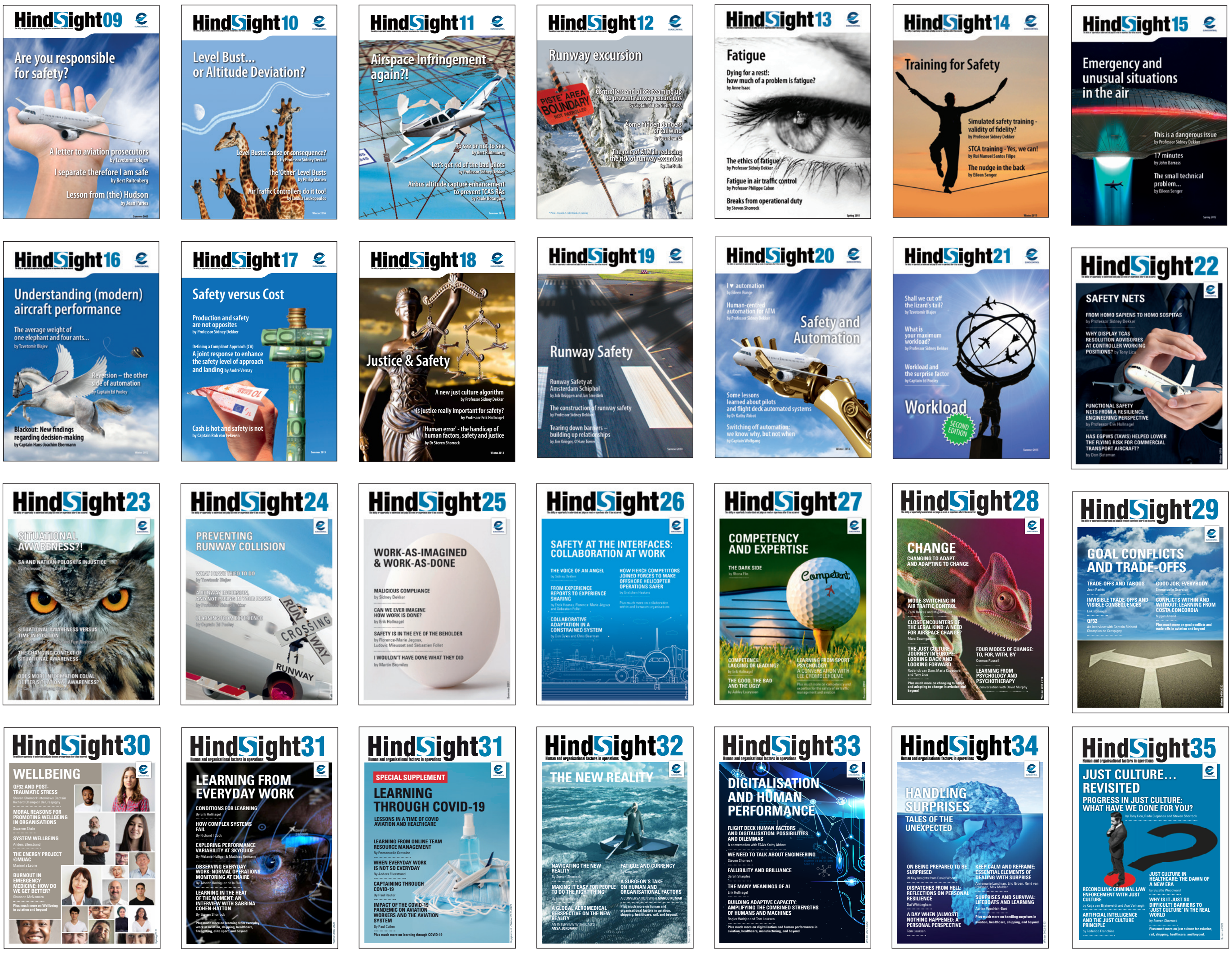
3. Readers appreciate simple and straightforward language, short sentences, and concepts that are familiar or can be explained easily.

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**

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*:
"PEOPLE IN CONTROL: STAYING IN THE LOOP"

This publication has been prepared under the auspices of the Safety Human Performance Subgroup, Safety Improvement Subgroup and Safety Team of EUROCONTROL.The Editor in Chief acknowledges the assistance given by many sources in its preparation.