HindSight 13

EUROCONTROL

Fatigue

Dying for a rest:
how much of a problem is fatigue?
by Anne Isaac

The ethics of fatigue
by Professor Sidney Dekker

Fatigue in air traffic control
by Professor Philippe Cabon

Breaks from operational duty
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EDITORIAL TEAM

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Does smoking cause disease?

I would like to start my editorial by thanking the Chair of the USA National Transportation Safety Board, Deborah Hersman, for kindly allowing me to use parts of her statement in the final report on the loss of control accident with Colgan Air.

On 12 February 2009, a Bombardier DHC-8-400, operated by Colgan Air as part of a code-share agreement with Continental Airlines, was on an ILS approach to Buffalo-Niagara in night VMC when control was lost and the aircraft crashed and caught fire in a residential area approximately 5 NM from the runway, killing all occupants and one additional person on the ground.

> **Fatigue, like alcohol and smoking, seriously affects us... there are studies which formally compare the effects of alcohol and fatigue on our performance.**

Tzvetomir Blajev

Editor in Chief of Hindsight
Fellow of the Flight Safety Foundation

The investigation was carried-out by the NTSB, 46 findings were recorded and a probable cause was determined: **"the captain's inappropriate response to the activation of the stick shaker, which led to an aerodynamic stall from which the airplane did not recover"** Additionally, four contributors were listed.

Fatigue was not listed as part of the probable cause but one of the findings reads **"The pilots' performance was likely impaired because of fatigue, but the extent of their impairment and the degree to which it contributed to the performance deficiencies that occurred during the flight cannot be conclusively determined".**

Both pilots were commuting to their Newark base. The first officer flew from Seattle to Memphis on a spare seat in one FedEx jet, and to Newark on another. The first officer was reported to have slept for 3.5 hours on the flights and 5.5 hours in the crew room. The captain had commuted from his home in the Tampa area, Florida, stayed overnight in the crew room with actual sleep time unknown and with an amount of potential accumulated sleep lost from previous days. Both pilots could be heard yawning on the cockpit voice recorder. The first officer can be heard saying *'oh I'm ready to be in the hotel room'* and a little bit later *'well this is one of those times that if I felt like this when I was at home there's no way I would have come all the way out here. but now that I'm out here'.*

During the Board's proceedings, the Chair of the NTSB proposed adding fatigue as a fifth contributing factor but the members of the Board rejected the proposal. In her statement in the report, a parallel was drawn with the impairment effect of alcohol. Nowadays, this impairing effect is well understood and accepted, but this has not always been the case. In 1967, the NTSB investigated a collision between a car travelling the wrong way on the highway and a bus which had resulted in 20 fatalities and 11 injuries. They calculated that, at the time of the collision, the driver of the car had a blood-alcohol level of between .15 and .19 (or higher). Nevertheless, their accident report stated that "there is a difference between being 'under the influence' of alcohol and varying degrees of drunkenness". The report went on to determine that the driver was not "drunk" because, prior to the accident, he had successfully travelled around town by car, talked with friends and **"therefore, it is logical to believe that he was able to read, comprehend and respond to traffic control devices, although probably not as well or as quickly as if he were sober."** In the report, alcohol was not cited as one of the probable causal factors; it was listed as a contributing factor. The Safety Board concluded that because the driver was not immobilised by the alcohol, alcohol was not a causal factor.

Nowadays, fortunately, we no longer have arguments like this. Society has placed strict limits on the use of alcohol in transportation and nobody is still interested in discussing whether it is a cause, a contributor or a factor. We have just put an effort to manage it.

Now, let us come back to the title of this editorial. The health warning on packets of cigarettes often reads "Smoking kills" or "Smoking causes cancer". Is this true? You may know

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someone who smoked all their lives but lived happily in good health till old age. Or, alternatively, you may know someone who never smoked but got cancer anyway. Does this mean that smoking doesn't really cause cancer? By no means! Years of research have proven that smoking causes cancer. This does not mean that all smokers will definitely get cancer. Neither does it mean that all non-smokers won't. It means that smoking greatly increases the risk of cancer. Smokers are, on average, much more likely to get cancer than non-smokers.

Fatigue, like alcohol and smoking, seriously affects us. You will learn in this edition of HindSight that there are studies which formally compare the effects of alcohol and fatigue on our performance. This, as with smoking, does not mean that if you are fatigued you will have an accident. But even in theory, there is no firm agreement on a definition of what 'cause' includes.

It may be time for us to stop arguing about how much of a 'cause' fatigue is and instead use the effort to manage it proactively!

And, to give credit to the NTSB, their list of recommendations concerning the Colgan Air accident includes one addressing the risk of fatigue. Ultimately, this is what really matters, regardless of how we formulate the explanations of the causes.

Enjoy reading HindSight!

Editorial note:

The theme 'fatigue' was chosen for this edition of HindSight in Autumn 2010 at the 27th meeting of EUROCONTROL's Safety Improvement Sub Group (SISG) of operational ATC safety specialists. Co-incidentally, as the recent well-publicised events in the US have shown, fatigue is an issue that demands our collective attention so that we better understand how it can affect our professional and personal lives. So, if you want to know more from an organisational or individual perspective about ATC fatigue-related risks to the safe operation of aircraft, I commend the unique set of articles contained in HindSight 13 to you.

Front Line Report:
It's about time – and how to use it

By Bert Ruitenberg

There's probably an article somewhere in this HindSight issue in which it is stated that it is very difficult for a person to recognise the symptoms of fatigue in himself or herself. Yet I can remember at least two occasions when I knew I was fatigued.

The first one was at the end of a trip to Africa in my days as a member of the IFATCA Executive Board. At that time I was also working full-time as an air traffic controller in The Netherlands, and even though I did enjoy some "special leave" days from my employer to help fulfil my IFATCA obligations, there were periods where my life seemed to consist solely of working days at Schiphol and/or days travelling to and from remote countries where I went to represent IFATCA in a meeting or at a seminar.

One of those trips had been so tightly planned that on the penultimate day I already found myself thinking more and more of the moment when I'd be slumping in my airline seat on the return flight, and hopefully getting some sleep. On the last day of that trip, my tunnel vision narrowed even further, focusing exclusively on the point when I'd be hitting my seat on board the flight home. I don't remember where I was exactly that day or what I did, but I vividly remember the feeling of only wanting to get on that aircraft and shut down.

I think I must have been asleep before the aircraft was airborne, and I didn't wake up until the flight attendant asked me to put the back of my chair in the upright position before landing. I actually felt physically better when I left that plane than I had when boarding it,

which I think is an experience that not many people will have had after a long-haul flight. Yet I've had it a couple of times under similar conditions.

The second time I knew I was fatigued was after an evening shift as supervisor in Approach Control at Amsterdam. I had slept reasonably well the night before, in a not-too-shabby hotel close to the EUROCONTROL Headquarters in Brussels (Belgium). The reason I was in Brussels again was IFATCA-related: there was a EUROCONTROL meeting that I had to attend on behalf of the Federation, and if I could be in my car by around 14:30 hours I'd have plenty of time to drive to Schiphol for my evening shift.

The meeting was rather interesting (which made it a remarkable event in itself, but that's not the point of this story) and I found myself quite engaged in the discussions. I was behind the steering wheel of my car ahead of my self-imposed deadline, and I arrived at the ATC building at Schiphol well in time for my shift.

That particular shift started off uneventfully, but things began to change rapidly. There was more traffic than was normal for that day of the week, the wind refused to adhere to the direction which had been forecast by the Met Office, and there were technical problems with the flight data processing system – the ATC computer, if you like.

On top of all that we had received the news that an historic aircraft, normally based at Schiphol, had apparently crashed somewhere just north of the mainland of our country. It was on a VFR flight, outside controlled airspace and definitely outside our TMA, but one of our colleagues regularly acted as a volunteer pilot on this aircraft, so im-

> **All controllers must remain conscious of their own responsibilities when it comes to being fit for work.**

Bert Ruitenberg

recently retired from working as a TWR/APP controller, supervisor and ATC safety officer at Schiphol Airport, Amsterdam, The Netherlands.

He was recently appointed as the new IFATCA Safety Coordinator.

mediately there were concerns in the operations room that he might have been on that flight.

I can tell you that I was very busy as a supervisor at that time. Not only was I trying to manage the traffic flow, the technical problems and the runway configuration(s) by coordinating the wind developments with the supervisors of the Area Control Centre and the Tower, I also had to put in considerable effort to make controllers focus on their traffic rather than worry about our colleague.

After what seemed like forever we were informed that our colleague had not in fact been on board the aircraft that had crashed, but the crash was confirmed, as was the fact that there were no survivors. The atmosphere in the operations room remained depressed after that message, which is not a pleasant mood in which to deal with more than the average number of aircraft.

My shift that day must have ended at the normal time, or perhaps even a little earlier than that because the night shift surely arrived ahead of time (knowing what had happened). I remember feeling very weary while driving home, yet after I got home I was too exhausted to sleep – strange as that may sound. Before going to bed I sat down at my computer and wrote a personal account of that evening, which seemed to have a therapeutic effect on me, for after finishing writing I slept for a long time.

So, if you think the moral of this article is "don't work for IFATCA", I'd have to say that I saw that one coming and no, that's not what this is about. Or maybe it is – if you consider working for IFATCA a lifestyle choice that I made.

As air traffic controllers we're regarded by "the outside world" as professionals in a job that is undoubtedly stressful,

but that also allows us plenty of free time. And let's face it, the people in that outside world are not completely wrong about the amount of free time we have. Of course, they conveniently overlook our working hours at weekends (a weekend is a strange concept of two recurring days off after five consecutive days of work) and/or on public holidays, and never mind the night shifts we have to work, but still, we controllers do seem to have more free time available outside our regular working hours.

Flexible and resourceful as we are (hey, we're controllers, remember?), we've come up with many ways to put this extra available time to good use. Some of us have side-jobs outside ATC, some of us prefer to live a long distance from the workplace where the quality of life is better. Some of us devote our time to intensive sports activities, some of us volunteer to work overtime as controllers when there are staff shortages. And some of us choose to be active in a professional organisation such as IFATCA. Lifestyle choices, all well and good.

But remember that sometimes, when you least expect it, those seemingly innocent lifestyle choices may turn around and bite you. Spending time away from your primary job, air traffic control, to focus on other activities may (and probably will) at some point interfere with your physical and/or mental resources when you need them most in that primary job. And the way in which a lifestyle based on structural overtime can bite you has been sadly illustrated by the recent developments in Spain.

I was lucky because my fatigue symptoms manifested themselves away from the operations room, but I realise that things could have been different. As regards my IFATCA activities, I learned to manage them a little better by including time for rest and recreation in my planning – in other words, I learned not to automatically accept invitations to speak at or attend meetings. I learned to look after my own well-being as a prerequisite for my activities.

So if I can wrap up this article with a message to all of you out there, it has to be that all controllers must remain conscious of their own responsibilities when it comes to being fit for work. Your employers have the responsibility to provide enough quality time in between shifts for you to get an adequate amount of rest – but it is your professional duty to use that time responsibly. Take care!

The ethics of fatigue

By Professor Sidney Dekker
Most people in ATC see fatigue as a physiological problem with psychological and physical consequences. A recent conversation with a student of mine persuaded me that fatigue is, at the limit, an ethical problem.

"So we had to do this investigation", my student said. It was an occurrence in one of the units run by his ANSP, and for which he and a group of others are mandated to carry out safety investigations.

"As usual," he continued, "we asked the controllers to rate the extent to which they felt fatigued during the time of the occurrence."

Even though they had been asking this question for a while now, it seemed that controllers had only recently started coming forward with self-reports about feeling fatigued. The scale on which they could rate their fatigue was 1 to 9. Nine meant they were wide awake, one meant that they were completely worn out.

"The controller reported a 3," my student said.

**Professor
Sidney Dekker**
is Professor and Director of the Key Centre for Ethics, Law, Justice and Governance at Griffith University, Brisbane, Australia.

Author of best-selling books on human factors and safety, he has had experience as an airline pilot on the Boeing 737

don't – and grumblings about being tired are often heard on the flight deck. I can only imagine how the controller on the ground must feel – he might have another six hours to go on shift when clearing us for descent to our home base.

So I was not surprised to hear that the self-report of being fatigued to the point of a "3" was taken both as data and a partial explanation for the occurrence in that sector. It seemed to make perfect sense, and not present any problems.

"It got us in serious trouble," my student said.

I looked at him. And I wondered why. He went on to tell me that he and a colleague had produced a draft report of the occurrence, which was circulated among the members of the ANSP's safety group.

> If a controller feels tired, i.e. too tired to work safely, then that controller should say so and decline to go on duty. That is the ethic.

I didn't think this was particularly striking. After all, an early check-in for a flight that takes me to a far-flung place in the southern reaches of Europe gets me, and the other pilot, pretty tired too. It gets worse because the return flight is on the same day, carrying us back up the globe to our northern origin in the dark for almost the entire way. Yawns get stifled—or they

"They told us that ATCOs have this ethic of self-control," he explained to me. Nothing new for him, to be sure, but he and his colleague had not realised how the increase in self-reporting of fatigue would have such interesting organisational and ethical consequences.

Self-control works in supposedly very obvious ways. If a controller feels tired, i.e. too tired to work safely, then that controller should say so and decline to go on duty. That is the ethic. Why was that a problem here?

"Well," he said, "we were on our way to publishing the investigation report, even without any identifying data, showing that a controller had violated rules and regulations, not to mention his own duty ethic, in working even

pay. Then, if something bad happens, you have to report your level of fatigue together with any other data about the occurrence. But how can you report this honestly if you know that you are not supposed to be both fatigued and working at the same time? No wonder there might have been underreporting of fatigue. Then, supposing that you do report that you were fatigued, the ethical dilemma gets kicked into the safety department. Should they publish a report that says that a controller violated the duty ethic, and the rules and regulations? With an increasingly litigious climate in a number of countries in Europe, and prosecutors on the prowl for easy judicial winnings, they might want to think twice before doing so.

Seeing fatigue as an ethical problem, rather than just as a physiological one, opens up new avenues for organisational and regulatory action. The standard response – trying to reduce or control fatigue as much as possible through scheduling, work hours, rosters, rotations, breaks, replacements – will never cease to be relevant and important. But what matters too is that fatigue is something that needs to be negotiated in the aftermath of occurrences.

when he knew he was so fatigued that it was impossible for him to work effectively."

In other words, fatigued to the point of a "three"? Then you can't work. Simple as that.

Yet this controller did. As do many, many others. Because, of course, what exactly is fatigued to the point of feeling "three" on a scale of nine? Fatigue is a hugely subjective, slippery experience with a variety and variability of consequences that is hard to pin down in any scientific way. And the very fact that you are fatigued makes estimating or even acknowledging exactly how fatigued you are very difficult.

Experience and reporting of, and regulations on fatigue put controllers in a variety of ethical dilemmas. The rules and the duty ethic say that you can't work if you are too tired to work. But if you decline to work, you put more pressure on your colleagues. Pressure that might indeed be one of the major sources of fatigue in your centre. So even if you might make it easier for yourself, you make it harder for everybody else. And in the end, all controllers

"We decided to drop fatigue from our report altogether," my student said. "Which a lot of people thought was a good idea. But the controller thought it was very unfair, making him look incompetent without a good explanation."

So there was yet another ethical dilemma. How true, how honest, can the investigator remain to the source? And what will that do to controllers' willingness to honestly report in the future?

Data on fatigue is important, of course, even when taking into account all its subjectivity and unreliability. And raising organisational awareness about it should be seen as a good thing. But ANSPs might want to think through the perils and consequences of asking people to self-report. You would not want to be surprised by some outside party who has got wind of willing, knowing violations that really represent a simple everyday reality – that of tired controllers doing their work.

Evolution is better
than revolution
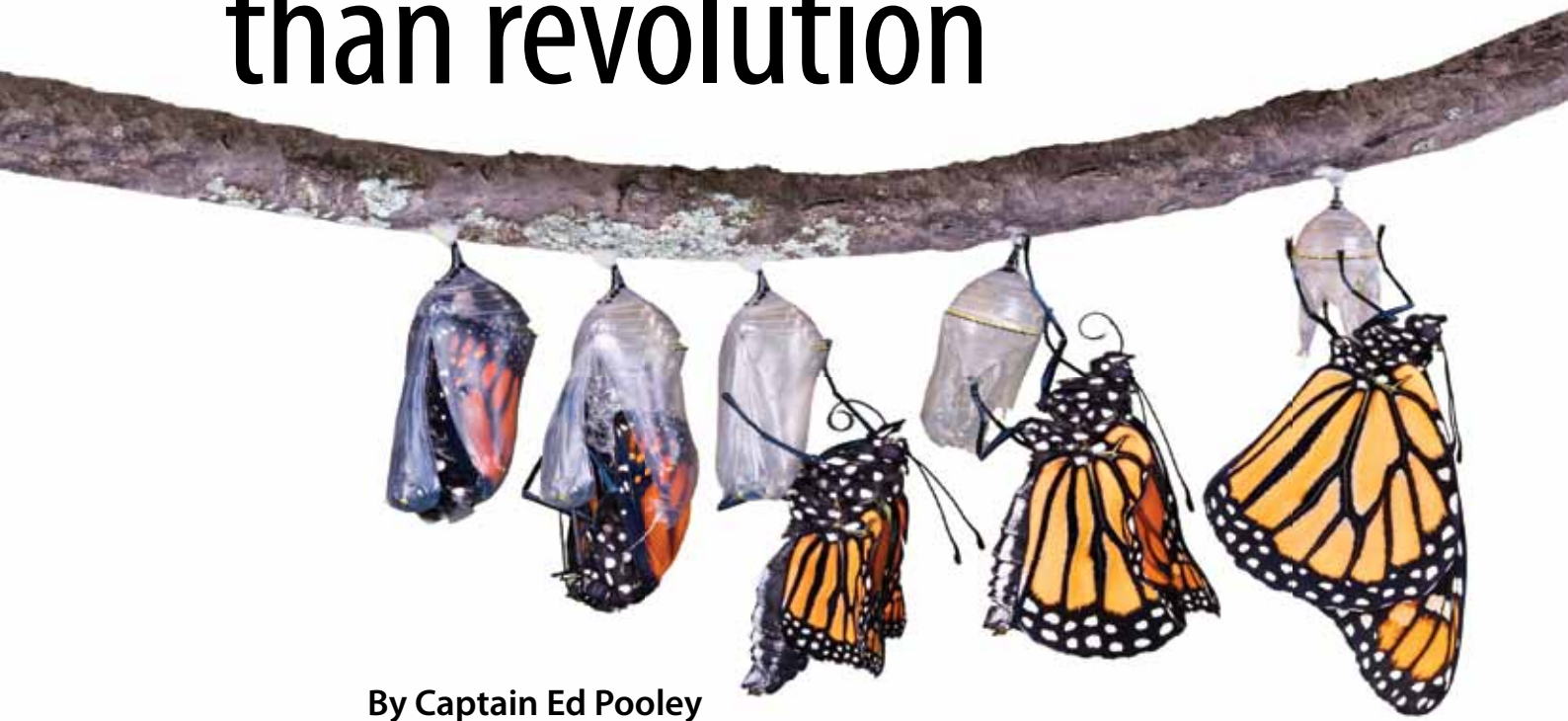
By Captain Ed Pooley
A lot has been written about fatigue in the context of shift-working professionals by experts in the study of it. Recent contributions sometimes seem to forget that many flight crew (I am one) have been fortunate enough to spend their whole operational careers under the protection of mandatory flight-time limitations (FTL) schemes.

Captain Ed Pooley

is an experienced airline pilot who for many years also held the post of Head of Safety for a large short haul airline operation.

He now works as an independent air safety adviser for a range of clients and is currently acting as Validation Manager for SKYbrary.

Of course, even the best of these have never provided comprehensive "fatigue risk management" and have often been slow to keep up with the changing face of aviation, notably long-haul multi-time zone operations and the implications of the growing dependence on automated flight management. But, coupled with sensible employer rules about commuting to work and a similarly sensible approach by regulators to the approval of justifiable exceptions, they have often been pretty successful in setting an outer boundary which has provided a proportionate defence against fatigue. Leading schemes like that of the UK have been in place for over thirty years. They have dealt fairly well with that element of the fatigue risk which derives from unreasonable planned demands in human performance on duty. And done so for a role which demands not only the intermittent management and execution of demanding tasks and the overall monitoring of complexity during quieter times but also the ability to respond to the unexpected at any time. A good FTL scheme has just left those fortunate enough to be working within it to act in as responsible a way in the run-up to assigned duty periods as they do when working them.

But of course it's no longer that simple, even if it ever was. Current attention to fatigue risk management for flight crew has unsurprisingly been driven by a few leading ultra long-haul operators concerned to maintain safety standards in their increasingly challenging environment and, almost in parallel, by leading short-haul operators who have been concerned to maximise crew productivity whilst effectively managing fatigue risks.

Both of these groups have needed to organise exceptions from the rigidity of typical FTL scheme rules and have been able to do so by providing their regulatory authorities with evidence of a comprehensive fatigue risk management system (FRMS) approach. Some of the FRMS approach depends simply on tailoring FTL schemes to their application so that equivalent risk management is achieved in widely differing applications. The rest of their focus has typically sought to ensure that the implications of off-duty behaviour are fully recognised and that the employer's 'just culture' environment has appropriate channels for the both reactive and proactive communication of specific fatigue occurrence and more general fatigue concerns.

There is one other vital point to mention about fatigue, which is personal. In a way, it is rather like low-level cabin air contamination. It affects superficially similar people differently. Sometimes the self-awareness of individuals is enough to act as their defence, but it is not always so straightforward. Hence the move to something more than just a 'good' FTL scheme.

ANSPs are beginning to approach this safety issue. As they do so, they are able to draw upon flight operations experience whilst taking account of both similarities and differences between the work of pilots and controllers. Some of these are obvious, others perhaps less so. On the differences front, controllers can stay in one time zone whilst on duty and whereas multi-crew aircraft present a formalised and ever-present opportunity for one-on-one teamwork between the pilot and the co-pilot, the circumstances of an individual controller are usually rather different. In addition, the management of controller working time can more easily take advantage of regular breaks during on-duty periods –

elsewhere in this issue is an excellent guide for controllers on how to make the most of scheduled breaks during duty periods. On the similarities front, both controllers and pilots share an exposure to the sudden onset of unexpected scenarios. They also, in many cases, share an exposure to workload that can, even in the absence of an abnormal or emergency situation, routinely vary dramatically from the very low to the very high.

ATM, however, seems to have had a history of a far wider range of duty time schemes than that seen on FTL and many of these have been far less likely to properly recognise the risk of fatigue even before the evolution to a potential FRMS. The FAA rules on controller rest periods between duties have been a salutary reminder that even 'leading' ANSPs have sometimes ignored what seems obvious to the accident investigator.

There is much for ATM to learn not only from the latest on aircraft operator FRMS initiatives and all the academic research we have recently seen on fatigue, but also from the history of leading FTL schemes and their evolution. Of course the broader approach which FRMS brings is the right one and provides a reliable way to ensure that the underlying rules set appropriate limits. But I would suggest that there is merit in proceeding at a moderate pace towards ATM FRMS rather than attempting to leap to the cutting edge in one go. Much of the essential wisdom of the rules which form the core of any FRMS comes in the first instance from a rational 'common sense' analysis of what is reasonable. New survey techniques, behavioural models and the valuable expert guidance now available can and should nowadays refine this process, but they may not necessarily be the best place to start if the rule-base has been absent or nominal in the past.

I will close by adding an important reminder which I could just as well have started with:

There is a crucial difference between tiredness, which is a normal and (provided it does not occur routinely) acceptable feature of life at work, and extreme tiredness (aka fatigue), which is an unacceptable state for any hands-on professional in any safety-critical industry.

A number of expert writers on this subject seem to use the two terms interchangeably, which is at best careless and at worst misleading.

Of course, I absolutely accept that it the recognition that it is the exploration of the boundary between the these two over simplified states which is where a comprehensive FRMS scores over the more limited scope of the old-fashioned rulebook approach of FTL. But I repeat that, as usual, if we want to have the least pain (and the maximum cost-benefit) from safety improvement, we should first take careful note of what has gone before as a prelude to targeting the all-embracing gold-plated objective. 🗲

By Richard "Sid" Lawrence

REQUEST FOR SUPPORT MESSAGE

Operator errors relating to hazard analyses in support
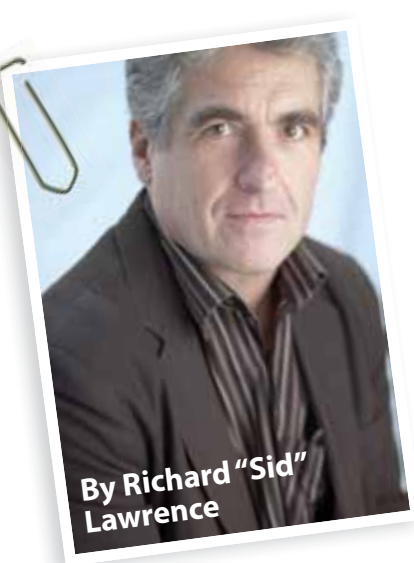
" During the past few months the EUROCONTROL Safety Alert service has been approached by a number of stakeholders requesting the promulgation of a safety alert covering a variety of topics. In the pages that follow, I aim to take you through a selection of the alerts that I hope will spark your interest.

As in the previous edition, my intention is to try and bring new information to the table. So, instead of a faithful reproduction of each alert, this section will also feature more in the way of feedback, responses, comment and analysis.

If you would like to know more about the EUROCONTROL Safety Alert service, register as a subscriber, submit a suggestion or have a subject that you wish to consider for a safety alert then please contact me at ***richard.lawrence@eurocontrol.int.***

The first safety alert to be reviewed is a Request for Support Message, Operator Errors relating to P-RNAV operations - informing Hazard Analyses in support of Safety Case development... "

Published 18 November 2010

Purpose

The message was requested by NATS to help them gather instances of operator errors relating to precision area navigation (P-RNAV) STARs, transitions and SIDs that could inform the hazard analyses needed to support the development of local safety cases for the introduction of P-RNAV operations. The data collected should help to ensure that appropriate mitigations are put in place.

Synopsis

Evidence considered so far has shown that operator errors (such as aircraft flying the wrong P-RNAV SID) dominate the occurrence reports within national and European (e.g. EVAIR) databases. This RFS sought further experiences (e.g. identified hazards, reported/recorded deviations, corrective actions, mitigations, best practices, etc.) from ANSPs and aircraft operators.

Regulatory requirements & guidance

Overall, it is expected that P-RNAV operations will be acceptably safe, subject to the implementation being undertaken with due reference to the regulatory requirements and/or guidance provided by:

JAA TGL 10, Rev1, Airworthiness and Operational Approval for Precision RNAV Operations in Designated European Airspace, dated Feb 05.

ICAO:
- Doc 8168-PANS-OPS/611;
- Doc 7030/4 - Regional Supplementary Procedures, EUR Region;
- Doc 9613 Performance Based Navigation (PBN) manual (3rd edition 2008) Vol 2 part B.

EUROCONTROL:
- NAV.ET1.ST10, Guidance Material for the Design of Procedures for Area Navigation, Edition 3.0, March 2003.
- EUROCONTROL Safety Argument for Precision RNAV (P-RNAV) in Terminal Airspace (Version 3.2, May 2008), Appendix A.

Alternatively, register your interest through the EUROCONTROL Website - Safety Alerts Board ***http://www.eurocontrol.int/safety/public/standard_page/safety_alert_board.html*** *or go to SKYbrary:* ***http://www.skybrary.aero/index.php/Portal:EUROCONTROL_Safety_Alerts*** *to access the Alerts featured here and all previous Alerts.*

P-RNAV operations - informing of safety case development

Support requested

Air navigation service providers and aircraft operators were requested to provide instances of:

- Operator errors relating to the use of P-RNAV operations in both TMA and en-route airspace.

- Equivalent experiences from other applications of performance-based navigation, such as: RNP0.3; RNAV (GNSS) Baro VNAV Approach; and General RNAV NPAs (i.e. LNAV only).

Feedback and responses

A total of 10 responses with comments were received: three ANSPs, one aircraft operator association, 5 aircraft operators (AO) and one aircraft manufacturer. In addition, 8 ANSPs (including one military) provided a 'nil return', indicating that they had not yet begun implementation of P-RNAV operations.

Although the returns show that P-RNAV is not yet widespread, it provided a limited amount of information that may be useful for later implementation. For instance, some of the errors identified were:

- **FMS use policy differences**
  It is the policy for one company which responded for their pilots to always use the FMS. Unfortunately due to the FMS/aircraft performance aircraft could not accurately maintain a published SID profile and the aircraft

were turning in early. The mitigation chosen to resolve the issue was to change the design of the SID. On the other hand, another aircraft operator recognising that the SID design was not compatible with FMS operation, allows the use of manual flying techniques (which are inherently less accurate than FMS).

- **Noise abatement** has a strong influence on SID design and subsequent AO operations. This does not necessarily raise any safety concerns but it is worth noting that environmental constraints are an increasingly important factor in procedure design.

- **Mixed conventional/P-RNAV ops**
  Another aircraft operator reported that it was sometimes necessary to use a mix of 'conventional' and PBN techniques in the same flight profile, often switching between them. The general advice is that such 'mixed' operations should be avoided.

- **Aeronautical Information**
  The importance of the procedures being properly and accurately described in relevant aeronautical information was highlighted by one ANSP.

One ANSP also kindly provided a copy of a report on the implementation of P-RNAV continuous descent approach (CDA) STARs and some of the difficulties experienced by ATC and the aircrew. Some of the more salient findings involved:

- The sometimes incompatible use of 'short-cuts' by ATC during CDA ops.

- Working with parallel altitude restrictions, i.e. the cleared altitudes assigned by ATC and the published procedural altitudes.

- The changing role of the controller, from proactive control to 'passive observer'.

- The additional training needs of controllers in order to fully understand how to handle flights involving CDA.

- Altitude restrictions for airspace reasons are not always viewed by some pilots with the same degree of seriousness as those in place because of physical obstacles.

- The mixed standard of R/T phraseology used in conjunction with rejoining CDA STAR (after a short-cut).

It is intended to analyse the information received and, if appropriate, to include it in the SKYbrary Hazard Log which is currently being developed. Moreover, as is normal with Request For Support messages, a shortened, de-identified synopsis of the feedback has been posted at the end of the RFS message on the Safety Alert section of SKYbrary.

Further reading

- **SKYbrary:** Area Navigation - http://www.skybrary.aero/index.php/Area_Navigation_Systems

- EUROCONTROL Navigation Domain: http://www.ecacnav.com/

SAFETY WARNING MESSAGE

Aircraft altimeter failure

Published January 2011

Synopsis

The SWM concerned a case of credible corruption of flight data and was based around an incident involving an altimeter failure on a PC12 aircraft. This caused a 2000ft discrepancy between the displayed altitudes on the aircraft's two altimeters. Subsequently, the Mode C transmitted by the aircraft and displayed to ATC showed the aircraft to be 2000ft lower than its actual level, which brought the aircraft into conflict with another aircraft flying at that level.

The sharp-eyed among you will recognise that this event has previously featured in HindSight 12 (pages 58 & 59) under the title, "Altimeter System Error, What's My Level?". Since publication of the article, the BEA report on the incident referred to in this alert has been made public:

http://www.bea.aero/docspa/2010/ec-h100602.en/pdf/ec-h100602.en.pdf
The BEA asked us to refer to the BEA report in the safety alert, and include in the body of the alert some evidence of the severity of this incident using extracts from the report such as:

"There was no triggering of the Short Term Conflict Alert (STCA) system at the control position or a TCAS alert on either of the 2 airplanes."

"Intrigued by fresh oscillations that made him think of wake turbulence, the co-pilot looked outside. He was then in visual contact with an airplane that was very close, slightly above and to the right."

"The minimum separation between the 2 airplanes could not be measured on the recording, the 2 radar plots being mixed together. The crews estimated that the separation was between 15 and 30 metres horizontally and about 100 feet vertically."

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SAFETY REMINDER MESSAGE

Runway incursion prevention – runway-holding position, stop bars and ATC clearance

This message was conceived following a request from the newly created European Working Group for Runway Safety. This group brings together, under the chairmanship of EUROCONTROL, the previous runway safety working groups established by EUROCONTROL and ECAST.

ICAO Provisions

The operation of stop bars is covered by a number of ICAO provisions, inter alia:

- ICAO Annex 2, Rules of the Air.
- ICAO Annex 14, Aerodromes.
- ICAO Doc 4444, PANS ATM.
- ICAO Doc 9870, Manual on the Prevention of Runway Incursions.

Published 4 February 2011

Synopsis

EUROCONTROL had been notified of incidents of aircraft crossing runway-holding positions and associated stop bars, which had been switched off, and then entering the runway without a valid ATC clearance.

In some instances pilots had reported inconsistent local policies on the use of stop bars (e.g. low visibility ops only, H24 operation on some runways, at some airports, in some States), which, in their opinion, contributed to confusion or to an assumed ATC clearance to proceed.

Analysis

It is important that the ICAO provisions relating to runway-holding positions, the operation of stop bars and associated ATC clearance are read and understood in conjunction with one another and in the appropriate context. ICAO Annex 2, 3.2.2.7.3 must be understood in the context of the preceding 3.2.2.7.2, which clearly explains that pilots can proceed beyond the holding position only when "…authorised by the aerodrome control tower", i.e. an ATC clearance has been issued.

Moreover, Annex 14 5.3.19.13 (Note1) and PANS ATM 7.15.6 and 7.15.7 are concerned only with the physical operation of the stop bars by ATC controllers. The observation that a previously lit stop bar has been turned off, or that a stop bar is not lit, should not be interpreted as a visual confirmation of an ATC clearance to proceed. **Note:** Subsequent to publication, the EUROCONTROL Runway Safety Project Manager also advises that *"The receipt of a valid ATC clearance can be confirmed by checking with the Tower and / or use of a cockpit (or driver cab) procedure e.g. to switch on forward facing lights if cleared for Take Off".*

To make things absolutely clear, in October 2010 the ICAO Aerodrome Panel proposed a revision of Annex 14, 5.3.19.13 (Note1) to the effect that the phrase "in conjunction with an explicit ATC clearance" be added at the end. This proposal was subsequently endorsed by the ICAO Air Navigation Commission and will be subject to ICAO State Letter consultation.

Safety reminders

Runway-holding position markings are the primary means used to protect the integrity of the runway. Where switchable stop bars are provided, either at a runway holding position or elsewhere in the taxiway system, they are there to support and reinforce designated positions and are not a replacement for them.

- Notwithstanding this general statement, stop bars are an important safety net at some aerodromes and ICAO Doc 9870 also provides other recommendations and best practices for both pilots and ATC controllers, namely:

  - **Rec 4.4 (Pilots):** "Pilots should never cross illuminated stop bars when lining up on, or crossing, a runway…"
  - **Appendix B - Best Practice for Flight Deck:** "Red stop bars should never be crossed when lining up on or crossing a runway unless, in exceptional circumstances, the stop bars, lights or controls are reported to be unserviceable, and contingency measures, such as using follow-me vehicles, are in force…"
  - **Rec 4.5.5 (ATCOs):** "Aircraft or vehicles should never be instructed to cross illuminated red stop bars when entering or crossing a runway."

- Therefore, it follows that before crossing stop bars pilots should:

  a. challenge ATC if they are cleared to cross an illuminated stop bar - **RED means STOP;**

  b. confirm that the stop bars are switched OFF except in the exceptional circumstances described in ICAO Doc 9870, Appendix B above;
     and
  c. have an ATC clearance to proceed beyond any holding position/stop bar, in particular those protecting runways.

- State authorities, aerodrome operators and ANSPs were invited to ensure the consistent operation of stop bars that protect the runway(s), e.g. low visibility ops only, H24 operation.

Feedback and responses

The alert generated a number of comments concerning the operation of stop bars. It is clear from some of these that there is inconsistent use of stop bars at many aerodromes which reflects the lack of a standard policy. That is why the European Action Plan for the Prevention of Runway Incursions, Version 2, contains a new Recommendation 1.7.6 "Ensure that Aerodrome Operators and Air Navigation Service Providers regularly review the operational use of aeronautical ground lighting e.g. stop bars, to ensure a robust policy to protect the runway from the incorrect presence of traffic."

Yvonne Page, the EUROCONTROL Runway Safety Project Manager and Chair of the European Working Group for Runway Safety, added that the responses to this alert have demonstrated the importance of placing the use of stop bars protecting the runway in the framework of a global network. Pilots need an airport to apply a stop bar policy consistently, with operational issues such as adequate time required to cross the holding position factored in. Air traffic controllers need the operating panel co-located with the working position. Aerodrome operators need to know about the operational needs to get the implementation right. Subject to appropriate local adjustments, an average re-lighting time of stop bars protecting the runway in Europe is in the range of 30 – 40 seconds.

Further reading

- ICAO Doc 9870, Manual on the Prevention of Runway Incursions.

- **EUROCONTROL Runway Safety Website**
  http://www.eurocontrol.int/runwaysafety
  - European Action Plan Prevention of Runway Incursions (EAPPRI) - 2003
    http://www.eurocontrol.int/runwaysafety/public/standard_page/ Awareness.html
  - Use of Stop Bars H24 Study Report
    http://www.eurocontrol.int/runwaysafety/public/standard_page/Awareness.html

- **SKYbrary:**
  - IFATCA Stop Bar Survey Report - December 2008
    http://www.skybrary.aero/bookshelf/books/602.pdf
  - Runway Guard and Status Lights article
    http://www.skybrary.aero/index.php/Runway_Guard_and_Status_Lights

SAFETY REMINDER MESSAGE

ANSP preparation for emergency, degraded modes of operation and unusual situations

Synopsis

Published 4 February 2011

A number of short-term, catastrophic failures of ATC system components e.g. voice communication systems (VCS) and flight data processing (FDP) at various European area control centres had occurred during recent months. In each case the ATC staff had responded promptly and efficiently to ensure that safety was not jeopardised.

These successes serve as a useful reminder to other ANSPs of the importance of being properly prepared to deal with emergencies, degraded modes of operation and other unusual situations that might threaten the provision of safe air navigation services.

Provisions

Provisions for dealing with emergencies, degraded modes and unusual situations are covered by, inter alia, the following:

- **ICAO**
  - Training Manual for Air Traffic Safety Electronics Personnel (ATSEP), Doc 7192. Advanced Edition 2009), Part E-2, Chapter 12.

- **EU**
  - EC Regulation 1108/2009, Annex Vb, 4 (c).

- **EUROCONTROL**

  - ESARR 5, Chapter 5.2.2.6
  - Guidelines for the Competence Assessment of Air Traffic Safety Electronics Personnel says in para 8.2,
  - Guidelines for Contingency Planning of Air Navigation Service, Edition 2.0.

Analysis

Catastrophic failures of complete ATC systems (or parts thereof) are rare. Nevertheless, to maintain tolerable levels of safety during periods of abnormal operations (i.e. the ability to "fail to safe"), it is essential that personnel connected with the provision of ATS are properly prepared to cope with a full range of situations. Recent experience has identified a number of common success factors:

- Strategies, plans and procedures to deal with emergencies, degraded mode and contingency operations should be in place. These need to be regularly reviewed and tested/exercised against relevant operational scenarios, e.g. equipment failures, airspace closures.

- Formal refresher/continuation training regimes to help prepare controllers, technical staff, supervisors and managers.

- Controllers must have a basic awareness and understanding of the main ATC system components, their functionalities and limitations. Equally, engineering and technical staff must have an appreciation of the operational impact of system disturbances - intentional and unintentional. Teamwork across all disciplines is essential.

- Swift communication (internal and external) is critical.

  - Inform neighbouring sectors (possibly in another country) so that they can help relieve the situation if needed.
  - If necessary, inform the CFMU as early as practicable so that appropriate ATCFM regulations can be applied quickly and efficiently.

- Letters of agreement, MoUs etc., checklists, emergency telephone numbers and standby facilities must be kept up-to-date if they are to be useful in potentially safety-critical situations.

- In-built fallback capabilities improve overall ATM system resilience.

- NSA oversight of contingency plans helps provide a focus on the investigation (severity and repeatability) and reporting of ATM specific occurrences as required by ESARR 2, Appendix A - 1.3.

Feedback and responses

ESSIP Objective GEN 01 - Implement European ANS Contingency Measures for Safety Critical Modes of Operation - requires ANSPs to be adequately prepared in order that they can continue to ensure the safety of ANS operations during a range of events including catastrophic ATC system outages. Latest monitoring of the ESSIP objective shows that over 75% of ANSPs comply with this requirement, but that still leaves a number of ANSPs who may need to do more to bolster their resilience.

Further information

EUROCONTROL

- Guidelines for Controller Training in the Handling of Unusual Incidents.
  http://www.eurocontrol.int/humanfactors/gallery/content/public/docs/DELIVERABLES/T11%20(Edition%202.0)%20HRS-TSP-004-GUI-05withsig.pdf
- Guidelines for Contingency Planning of Air Navigation Service, Edition 2.0.
  http://www.eurocontrol.int/ses/public/standard_page/sk_sesis_guidelines.html
- Managing System Disturbances in ATM, Edition 1.0.
  http://www.eurocontrol.int/humanfactors/gallery/content/public/docs/DELIVERABLES/HF47%20(HRS-HSP-005-REP-06)%20Released-withsig.pdf
- Guidelines for the Competence Assessment of Air Traffic Safety Electronics Personnel.
  http://www.eurocontrol.int/safety/public/site_preferences/display_library_list_public.html

SKYbrary

- Emergency and Contingency Category.
  http://www.skybrary.aero/index.php/Category:Emergency_%26_Contingency
- Guidance on Degraded Modes Safety for Operational Engineering.

Case Study –
It's a long way from Tipperary

By Bengt Collin, EUROCONTROL

Eight months earlier

The Controller was sitting in front of the computer, a battered old grey desktop with one of those bulky 14-inch monitors. The room was warm; at least the heating is working in this old part of the building. Apart from Susan sitting on a brown sofa reading a book at the opposite end of the room, he was alone. Susan was constantly reading philosophy books such as Plato; he preferred the Swamp cartoon magazine instead. But she was OK as long as she did not discuss anything with him.

He clicked himself through a questionnaire. It was one of those multiple-choice type questionnaires which was part of the yearly periodic training he had to pass to keep his licence valid - boring if you asked him. The questions were available weeks ahead of the test, but as usual, he waited until the very last day to practise. He'd invented his own method for passing: if a question was too complicated he memorised which answer option from the multiple choices was the correct one. "What is the lowest obstacle-free altitude to vector an aircraft in the control zone?", He had to remember it was answer option C.

Bengt Collin

works at EUROCONTROL HQ as an Senior Expert involved in operational ATC safety activities.

Bengt has a long background as Tower and Approach controller at Stockholm-Arlanda Airport, Sweden

Two days earlier he had passed the practical part in the simulator without having to do anything. The simulator had a few minor technical problems, time pressure did not allow everybody to work in position. He did not reflect any more about this, the circling approach scenario he found strange, they never used that, why should they? After all, both runways were equipped with ILS so why choose this scenario? He kept quiet; better not to upset anybody by asking stupid questions.

Seven months earlier

The airline had some twenty aircraft, business was brisk, but like most other airlines they had limited resources. Mind you, the introduction of a new aircraft type would help, trouble was new SOPs would have to be developed and written. As the new Chief Training Captain the job fell to him even though he had limited experience in developing them. He had got his training job based on previous experience flying similar aircraft, although not the same type. This was the best they could come up with; having the aircraft on the ground didn't bring in any money. It was decided he would take the lead, assisted by one person from the airline navigation service department.

Together they started the work by using the manual from the aircraft manufacturer, added a few things that he thought were important and briefly checked the SOP from another airline, kindly provided by an old friend of his wife. Good thing that this old friend had been in such a good mood after all that happened, the instructor thought, remembering some unforgettable jacuzzi and champagne events.

Two weeks earlier

The airline bought time at another airline for the initial type rating; six months later he was back for his first recurrent flight training. Following a long briefing, he and a First Officer from the airline spent four hours flying - two hours with him in command, two hours with the First Officer. At the de-briefing his First Officer questioned some of the procedures from the SOP, especially the one on circling to another runway. Well, this is how it is described in the SOP, the instructor leading the debrief answered. The First Officer stayed silent for the rest of the session.

The evening before

It was snowing. The Captain left home at eight o'clock in the evening to get to work; six hours travelling time ahead, it was his own choice. Being a pilot was not easy, gone were the golden days in aviation. He was happy to have a job after all; his wife was happy too but refused to move. "Who knows how long you will stay with this job?" she said, in her warm soft voice; "we can't move just now". "The kids are in school, they have their friends, we have our life here". It was his lot just to accept. He took it day by day nowadays. Perhaps he could get a job nearer home in the future, this thought kept him going. At least the road conditions were OK; he had a long drive ahead of him followed by a flight to his airline airport. This was the standard procedure, he frequently got a lift with the nightly cargo flight, saved both time and money.

Check in at work was 6.00am; from then until 2.00pm he'd be on airport standby. Should give him time to relax

in the briefing room; what he absolutely did not need was five legs to fly before ending up at a hotel in the middle of nowhere.

He should have listened more carefully to his mother advising him to sell hamburgers instead. It stopped snowing.

The night before

1.30 in the morning, their lovely son born four weeks ago was crying, not extremely loud but since everything was very quiet around their house at this time of the night, the Controller could hear it only far too well. He tried to pretend he was sleeping, hoping his beautiful wife would jump out of bed with a smile on her face.

"It's your turn", she said, almost whispering. "I've already been up four times while you have been sleeping". "How can you sleep with this noise?" she continued, turned away from him, pulled the duvet around her and started snoring.

He started by checking the status of the baby, dry, OK then probably hungry. He fed him, started singing English folk songs in his discrete baritone voice, very quiet so as not to wake his snoring wife. "It's a long way to Tipperary, it's a long way to go, it's a long way to Tipperary, to the sweetest girl I know…"; the baby boy threw up on his t-shirt. Was it his song or something else which had made him do it? This is going to be a long night, he thought; I'd better have a cup of tea.

6.00 a.m.

He'd arrived at the airline briefing room at half-past two in the morning, got some rest on the crew room sofa. At six o'clock he had a quick wash, put on his uniform while sipping his double espresso. I don't feel too tired after all he thought, starting to read the morning paper that had just arrived. Another glorious victory for my favourite team he noted, this will be a great day.

6.30 a.m.

At 5.30 the Controller had had to wake his wife to tell her that their son was finally asleep. "Why wake me up to tell he is sleeping?" she asked. He arrived at the tower in a more or less unconscious condition one hour later. Earlier that month he had had some days off, looking after his son. Some of his colleagues couldn't understand what it was like having small children; they just did not accept that you sometimes needed to stay at home. To be fair one reason for this was that one or two colleagues frequently used small children as an excuse for taking a day or two off; strangely this often happened on sunny summer days. Anyhow here he was, ready for duty. But tired.

7.00 a.m.

The lady at the crew check-in, in her early forties, was well dressed and always very nice. She called for him, looked at him with a discrete professional smile; "sorry to disturb you dear, we need a Captain for the eight o'clock flight to Noselake, it is one of our new aircraft and you are the only qualified Captain available".

For a moment he thought about saying something, but finally decided not to. He checked the name of his First Officer; he'd never worked with him before. Fairly new, that was all he had on him.

Sometimes the newcomers have things more up to date; he tried to cheer himself up, he often did. If no one gives you feedback, do it yourself.

8.30 a.m.

ILS runway 14 was out of service, it had been since yesterday - planned maintenance work which had been known about for a long time. The stiff southeasterly wind meant that ATC needed to continue using runway 14. Normally the aircraft should be vectored to final runway 14 for a straight-in approach, but because of the relatively low cloud base they used ILS runway 32 followed by circling to runway 14. "You have all been trained in that procedure in the simulator" the supervisor told them. Although knowing this had been six months ago, he kept a low profile. As long as I can park my car close to the building I'm happy.

8.45 a.m.

"Did you know ILS runway 14 is out of service?" he asked his First Officer. "They say it's published in a NOTAM, I haven't seen it". The time for briefing before the flight being short, he did not blame himself or his First Officer for having missed it. His First Officer did not reply. They started the descent.

9.04 a.m.

They broke cloud at 1000 feet; the reported visibility of 3000 metres was probably correct. Not that they thought about it at the time, more what they could remember at the interview afterwards. He turned left for a right-hand circuit runway 14; the First Officer reported this to the tower Controller.

Case Study - It's a long way
from tipperary (cont'd)

Case Study Comment 1
by Dragan Milanovski

"Nice to be on the ground soon", he said to the First Officer, "I need some fresh air, I feel sleepy". He noticed lower clouds ahead, he couldn't turn closer to the airport, this would make the inbound turn too steep, instead he continued towards the west. "Can you still see the airport?", he asked his First Officer. The First Officer looked out of his right window, "No, I actually lost it", he replied after a few seconds. The ground was still visible though, but without any point of reference.

9.05 a.m.

He was sitting comfortably in his chair in front of his working position. If the aircraft doesn't disturb me on the frequency I could have a quick nap, he mused. He then laughed to himself, if this was the worst problem he could think of, he did not really have any problems at all. Now, where was the aircraft? He looked out and all he saw was clouds. For a moment it was like his heart stopped, he looked on his radar screen and relaxed, there it is way out west, the pilot needs to turn inbound soon, "A-Line 123 turn right towards final runway 14".

Two months later

"You were lucky, you passed just over a mast, did you know that?". The investigator talked to them in a calm, friendly way. "Well, let us start with your description of what happened".

As a matter of routine he also asked the pilots (and later the controller) about the 24 hours prior to the incident: "Did anything in particular happen? Did you sleep well?" etc. Yes, they all did.

This unfortunate incident with a lucky outcome involved tired professionals who made omissions days before the event.

The Captain wrote the SOP for the airline's new aircraft type. This was the best that the airline could come up with, but was it enough? The fact that the Captain accepted the task suggests he was probably up to the job. He even went to the trouble of asking a favour from an old friend, and checked briefly the SOP of another airline. It is not quite clear why the other airline's SOP was "briefly checked" and not in detail (Were the jacuzzi and champagne memories too distracting?). The new SOP was probably not perfect, but we can hardly blame the Captain for that.

Where he could have done more was at his first recurrent flight training, when the First Officer questioned the circling to another runway. As the new chief training Captain, he should have considered the comments made by the First Officer and the procedure from the SOP should have been crosschecked. Especially in this case, with him being aware that there could have been omissions in the new SOP. Instead, he ignored the situation when the procedure from the SOP was used as an excuse by the instructor leading the debriefing.

The Controller received the yearly refresher training, which it turns out was not as effective as expected. The fact that he invented his own method to pass the test suggests that the questions could have been poorly designed (a competent Controller found some of the answers complicated), but this is not an excuse for the Controller's

unprofessional behaviour. The circling approach that was "never used" was included in the practical training (obviously for a reason). But if it was considered important, the training should have been re-scheduled following the technical problem with the simulator, to allow everyone to work in position.

The incident took place several months later caused by the shortcomings in the circling procedure in the new SOP and in the Controller's refresher training. Other circumstances, such as scheduled ILS maintenance, poor pre-flight briefing and complex meteorological conditions also contributed to the event. Nevertheless, I still have the feeling that the incident could have probably been avoided if both the Captain and the Controller had not been seriously suffering from fatigue.

The Captain was suffering from cumulative fatigue due to irregular hours, uncertainty, long night commutes and poor quality sleep (on the crew room sofa). The Controller experienced sleep loss on the night before the shift. In both, the effects on human performance are similar, including reduced attention, increased reaction time, poor vigilance, short-term memory impairment and reduced flexibility.

This explains why the Controller "drifted away" in position (the comfortable seat contributed too) instead of following the aircraft visually. He probably would have made the call earlier and prevented the incident.

It also explains why the Captain did not see the NOTAM before the flight, did not consider the visibility at the time of the approach and reacted slowly to the low clouds, while thinking about enjoying the fresh air after landing.

Can situations involving tired pilots and Controllers be prevented?

From early in training, Controllers learn that good sleep is vital to fight fatigue, as well as proper nutrition, stress control and regular exercise. Despite all the efforts made, a situation where the Controller feels tired at work (for any reason) is unavoidable. Most of us can still do the job at an acceptable level while being a little tired. To make things more complicated we all have different thresholds and we

> ## From early in training, controllers learn that good sleep is vital to fight fatigue, as well as proper nutrition, stress control and regular exercise.

all deal with fatigue in a different way. Some cope more effectively than others. Some will never admit suffering from fatigue and try to push the limits of the human body, others will exaggerate the effects even when being a little tired.

Managing fatigue has become even more difficult for pilots. "Gone are the golden days in aviation". Irregular lifestyle, maximum hours, long commutes and being away from home have become standard. Not forgetting less and less attractive employment conditions and the ever-increasing production pressure.

Dragan Milanovski

is ATC training expert at the EUROCONTROL Institute of Air Navigation Services in Luxembourg.

Most of his operational experience comes from Skopje ACC where he worked for a number of years on different operational posts.

Now, his day-to-day work involves ATC training design as well as Initial Training delivery for Maastricht UAC.

RECOMMENDATION:

The fatigue and sleep management training package seems like a good idea to start with. However, more needs to be done.

Most of the training packages on the subject that I have seen increase awareness of the effects of fatigue and deal with tips and tricks on how to manage fatigue. However, refreshing knowledge periodically and increasing awareness will not prevent the rare exceptions, where tired professionals work in position. Sooner or later everyone will find himself/herself in a situation where the fatigue management strategy has failed and, you feel tired and have to go to work (remember the poor Controller from this story?). Then you will have to answer the following questions: How tired are you on a particular day? What does it take to declare yourself unfit for work due to fatigue? Where do you draw the line?

Case Study Comment 2
by Razvan Guleac

Reading the article made me think that actually these circumstances are far from uncommon. In some of the cases, incidents like the one presented here happen, in other cases, such incidents are "missed" by a narrow margin, being mitigated by the implicit design buffers or safety nets, which are nevertheless not intended to compensate for procedural or operational errors. From all the angles of the story (controller, airline, pilot), a flavour of the problem is taking shape: CIRCLING.

Razvan Guleac

has a Master's degree in Aerospace Engineering; started his career as an ATCO specialised in information management (NOTAM) and in 2000 he became a PANS-OPS (ICAO Doc 8168) procedure designer, working within the Romanian CAA Navigation Department for more than 7 years. Since 2006 he provides services to EUROCONTROL as an Air Navigation Services Specialist and currently supporting the European AIS Database (EAD).

The first aspect that draws the attention is the controller training for the renewal of the ATC licence. Not all the scenarios are necessarily comprehensible or within "normal" limits, but then again, are they supposed to be? The goal is to tackle non-routine and difficult cases that most of the time will not be encountered; however, when they occur, they could potentially lead to critical situations. Sometimes, it is possible that, with seniority, controllers will be less encouraged to challenge such scenarios. Partly because human beings usually don't like getting out of their comfort zone, but perhaps also due to the fact that it is not easy to admit not knowing or understanding the details of a specific situation. The method developed by the controller I find dangerous, since it might induce the feeling that everything is OK as regards knowledge and best practice, which obviously it is not!

The second "enabler" of the incident is, in my view, the airline's standard operating procedures (SOP) for the newly introduced aircraft. SOPs might prove to be genuine safety issues if they are not given the right level of importance, both in developing and applying them. Returning to our story, we can see that both elements were overlooked. The development was entrusted to the chief training captain, who had limited experience in writing the operational documentation (sometimes it is said that writing technical and operational documentation is an art in itself). Although the basis for the development was not wrong (the aircraft manual, a similar SOP from another airline), important references, such as the ICAO SARPS, e.g. PANS-OPS (Doc 8168, Vol. I), the European Union Regulation, e.g. EU-OPS 1, etc. were

not considered. A second element of no lesser importance is the recurrent flight training following the initial type rating. The feedback from the first officer questioning the procedures (circling included) was dismissed with too much ease, considering the fact that this was based on a newly developed SOP which needs, if not as part of its validation, at least as a best practice, a 'flight check'. The reply of the leading instructor at the debriefing falls under those "chicken-and-egg" situations: the SOP was perhaps not entirely adequate, but how can you improve it if you don't accept feedback?

The scene set-up on the day of the incident is a classic: ILS RWY 14 unserviceable (maintenance) and meteorological conditions requiring an initial approach to RWY 32 followed by a circling to land on RWY 14. However, as classic as it may seem, neither the crew (with their limited experience of the new aircraft, including its operating procedures), nor the approach / tower controller (who did not bother to reflect more on the simulator exercise on circling) were ready for it. The controller's thoughts at the beginning of the long-gone and almost forgotten simulator scenario were "never used that, why should they?" And this is in fact true. The preferred options for approaches are: precision (ILS), non-precision / RNAV and, only if none of the above is available, visual manoeuvring (circling) option.

There is one element that might not score highest in the overall enabling factors, but which is quite important: the lack of awareness concerning the ILS RWY 14 "out of service" NOTAM. In this particular case, a correct and thorough pre-flight briefing would have

allowed the crew the time to digest the approach conditions and options at the destination airport. This would have probably not achieved much, but would have slightly alleviated the decision-making process in the critical phase of approach, where the cockpit workload is very high and does not allow much time for the "unexpected".

Since circling is used, most of the time, as a back-up procedure and often has limited track guidance, continuous visual contact with the runway environment is essential.

Nevertheless, the most critical issue that comes out of this story is for me the actual execution of the circling procedure. Since circling is used, most of the time, as a back-up procedure and often (as in this case) has limited track guidance, continuous visual contact with the runway environment is essential. This is the only reference the pilot can rely upon, in a procedure where the trajectory / position of the aircraft is less accurate, at least until the very last turn and alignment for the final approach and landing. The fact that the first officer said that he had lost visual contact with the airport (the captain not being in a position to have this view, due to his left-side position with the airport on the right side) should have triggered the decision to initiate the missed approach

for the procedure (ILS RWY 32) from which the circling has been initiated. Instead, the pilot in command continued the approach, placing the aircraft outside the protection area designed for this procedure.

The last (but not the least) element was the controller's interference with the circling procedure, manifested by the "turn right" instruction to the crew. Apart from the fact that when he did this he assumed responsibility for the terrain / obstacle clearance of the aircraft (as opposed to the procedure where the pilot is responsible for maintaining the operating minima), his action could have been confusing for the pilots, who did not expect vectoring.

RECOMMENDATION:

The qualification and recurrent training (both theoretical and practical) of the pilots regarding circling has to be regarded as being of the utmost importance, both personally and at airline level. The execution of a circling manoeuvre requires conformity with the Procedures for Air Navigation Services (e.g. PANS-OPS) recommendations and certainly adherence to the aircraft operators' SOPs. Which, in turn, have to be correctly developed.

This recommendation can also be extended to non-precision approach procedures. Even if they ensure a better degree of predictability for the trajectories of aircraft compared to circling, they are still regarded as safety issues which can lead to CFIT incidents.

Case Study Comment 3
by Marie-Louise Berry

Ah!! Just had my siesta and feel so much revived now!..
isn't this a phrase we commonly hear? When fatigue hits us, we all know our brains will not function 100%. The problem nowadays is, do you have enough time to sleep, to get your well deserved rest? I think these are questions which in this scenario both the ATCO and the captain did not spend too much time thinking about. Do we realise the consequences of fatigue?

The ATCO in the story did realise however that he has no choice but to pursue his professional career and to keep his family happy as well. The captain has no choice but to drive for hours on end to get to work. Is there a measuring tape to tell us how much we can push ourselves, and to which limit? Is there an indicator to tell us that now we are tired and our brains will function in a 'slower' mode, and that in our career this might lead to a disaster?

The exhausted controller and father was not having a great day, and to make things worse, on top of his lack of energy he realised that he had followed his periodical training with a pinch of salt. And do we blame the ATCO? Hundreds of questionnaires pass under your hands in night shifts, and we all know they spell 'Boredom' so really, I don't blame the ATCO for shelving his papers for weeks! What is more motivating than a questionnaire??!! The situation did not help much when he realised that on the one occasion he had a chance to try this 'rare' circling procedure, he had missed it due to faulty simulators. Poor ATCO. Knackered and lacking knowledge and experience of this scenario.

The good old captain, after a long trip to get to work, gets a flight with a new pilot. Was it the fatigue plus the lack of experience of the first officer that they both missed the NOTAM. Is this something which the good old captain had been doing for years before every flight and now had forgotten! Could it be the effects of fatigue?????????

Was enough attention given to the correct development of the SOP for the new aircraft? Was the SOP a contributing factor to this near-miss?

Like a little devil, the weather is always there to jump out at us when there is something else wrong already, such as in the scenario, where the ILS was out of service.

So in addition to the captain's fatigue and the first officer's lack of experience, the weather could only make things worse. The positive thing about the captain is that he did admit that he felt sleepy.

Leroy is in "power save" mode again...
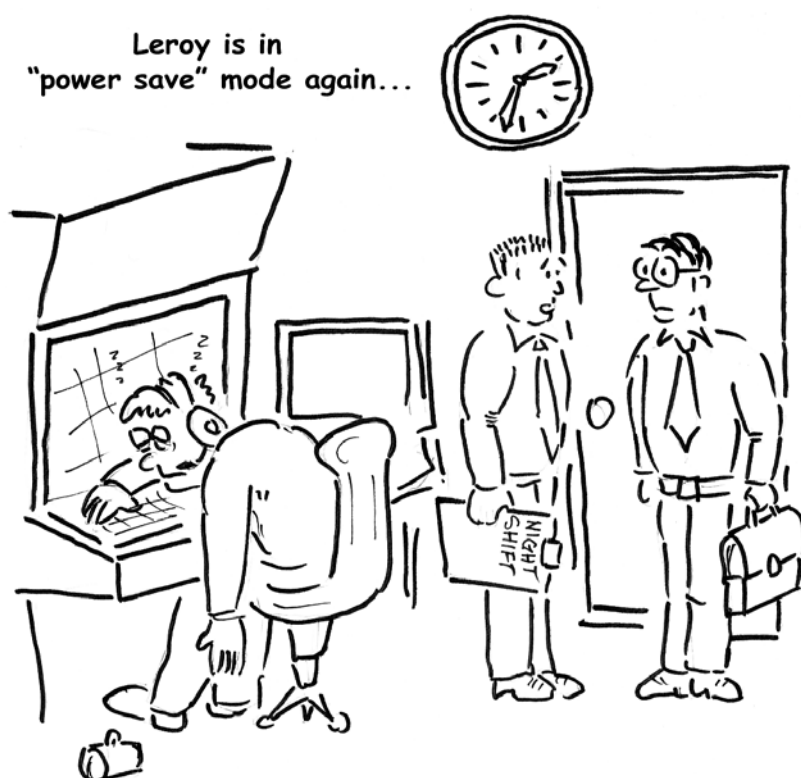
It is common for understaffed systems to force ATCOs/pilots to work overtime, thus leaving them tired; therefore work schedules should be revised in order to prevent ATCOs and pilots from being tired on the job.

We should act responsibly with ourselves and note our limit of exhaustion. Fatigue is associated with mental (and/or physical) shortcomings. This could potentially lead to a decrease in mental attention which could be disastrous in tasks which require constant concentration.

Fatigue is a threat to aviation safety, but it is a normal response to lack of sleep and long shifts where the most effective treatment is adequate sleep. Fatigue is rarely mentioned in our ATC world, it seems that we are born to learn how to deal with it the best we can; however, bear in mind that when an incident happens, your level of consciousness is the first thing that will be questioned!

…..shouldn't you go and have a power nap now??… I will sing a song for you… it's a long way from Tipperary…..la la la…

RECOMMENDATION:

Be honest with yourself - if you are tired, admit it. Also, make your colleagues (supervisor) aware of your situation. After all, it is YOUR responsibility to be fit for work.

Case Study Comment 4
by Captain Ed Pooley

The main finding from this incident should be that the captain failed to prepare for and carry out his duties as an aircraft commander in an acceptable way. And that is not just a single failing but an attitude-to-the job problem. That he was not 'rescued' from a potentially dangerous circumstance of his own making by the controller is unfortunate but is secondary, since any aircraft commander retains sole responsibility for the safety of his aircraft even when under orders from ATC in controlled airspace.

However, the majority of sub standard human performance by professionals in aviation can be associated with the context for the performance of their duties provided by their employer. In this case, we know that the captain worked for an airline which had failed to risk-manage its operation in an appropriate way. On the evidence provided, the new chief training captain was not 'fit for purpose' in that post.

In any properly managed airline, even quite a small one, he would not have been appointed – or if he had would have been removed from his post fairly quickly once his lack of the necessary qualities for such a senior appointment became apparent. Remember that, in any properly regulated jurisdiction, a candidate for the post of chief training captain for an AOC holder would be subject to pre-approval

Captain Ed Pooley

is an experienced airline pilot who for many years also held the post of Head of Safety for a large short haul airline operation.

He now works as an independent air safety adviser for a range of clients and is currently acting as Validation Manager for SKYbrary.

by the regulator. Anyway, with my own perspective clear, let's look at the three main players one by one, taking note of the institutional contexts:

The **Chief Training Captain** is the root of the problem. Unfortunately, because he provides a clear indication of the relative importance accorded to operational safety generally at this operator, it is unlikely that his fellow senior managers in flight operations were of a radically higher calibre. Pilots in an airline are recruited and managed according to various priorities. Because these priorities affect them all and result from the collective style and substance of the flight operations management team (who themselves will be influenced by the priorities of their corporate general management) the majority of the pilots in each airline will share a common outlook on operational safety. Pilots are people who can be inspired (or otherwise) by the grasp (or otherwise) which those who run the company have of the operational challenges they face. If inspired, they will try especially hard to deal with their challenges, so that the airline can prosper by minimising its corporate exposure to the business risks, both direct and indirect, which follow a fatal accident.

Our chief training captain adopts an approach to his SOP task which is flawed. Of course one starts with the manufacturers' aircraft type manuals. But the procedures of 'another airline' should be an irrelevance at the outset of the process. The way to proceed is to carefully consider the generic aircraft type procedures provided against the existing general operating procedures of one's own airline as already approved by the regulator. Some 'issues' will probably arise and should be resolved by careful adjustment of one or other set of procedures, using extreme care before adapting any of the manufacturers' generic procedures, since these will

have been subject to very careful construction if for no other reason than that of product liability. Any changes which the reviewing manager - in this case the chief training captain - feels are needed should have been peer reviewed before adoption. Peer review is not achieved by adding the assistance of "one person from the …navigation services department". And whilst, if my earlier argument that the senior flight operations managers in any given team are likely to be of similar calibre is true, the effectiveness of peer review may be reduced, at least it spreads the responsibility.

The conduct of the chief training captain during his subsequent recurrent training detail provided further evidence of his own lacklustre performance in helping set the scene for this incident. The instructor pilot demonstrates the complete absence of the inquiring mind so vital for all instructors when he 'puts down' the queries of the first officer and the chief training captain stays silent too. This serves only to reinforce the picture of a poorly-led flight training team who know their place and feel unable to pursue a debate on SOPs because, presumably, they know who keeps them in their instructor role whether directly as employees of the operator or indirectly as employees of a third part training provider…

I have already attributed the incident directly to the **Captain** of the aircraft whilst pointing out that this is the

Whilst the actions and attitudes of every professional pilot and controller are their own and professionalism is an essential feature of task focus, the ethos prevalent in an employing organisation counts for a lot too.

beginning rather than the end of the analysis. No surprise in such an airline that he displays such an unprofessional approach to his job. In a well-run carrier, commuting to work by flight crew is controlled by company rules, sometimes but not always because of regulatory expectations. In other situations like the one here, personal responsibility is all that remains of the defence against fatigue. Lodgings, or even a flat near the place of employment (or maybe a night in a hotel - they aren't all expensive) is the correct alternative to driving through the night or taking a flight or other transport in the period immediately before the commencement of a duty period. The 'not-getting-away-with-an-airport-standby' routine is not the first time it's happened and neither is a crew pairing you've never had before. The latter in particular shouldn't make any difference at all to

So what about the "rescue service", our similarly fatigued **Controller**? Most of the time, pilots who fail to follow an airborne procedure when on an IFR flight plan in controlled airspace can rely on the watchful eye of a wide-awake controller to act as their "guardian angel". But unfortunately, this time only fate separated the aircraft from the mast

ler are their own and professionalism is an essential feature of task focus, the ethos prevalent in an employing organisation counts for a lot too. In this case study, we see an airline which is being badly run not (I suspect) simply because of our old friend 'commercial pressure' but because the senior mangers there have failed to implement robust measures which will provide for appropriate levels of risk management. The appointment and performance in-post of flight operations managers could be the place to start the necessary safety improvement. At the ANSP, similar managerial deficiencies can be seen with incompetent managers presiding over a not-fit-for-purpose controller training and assessment regime which brings out the worst in the controllers who are subject to it.

the effectiveness of flight deck teamwork in a well managed airline. But whatever 'sort' of airline one works for, not making yourself vulnerable to fatigue is an essential piece of personal insurance as an aircraft commander when there is (nowadays) probably something like a 95% chance that a flight will be uneventful if SOPs are applied and only a 5% chance that it will be 'interesting'.

In respect of the circling approach which went wrong this time, there was inadequate pre flight planning, an inadequate approach briefing and, clearly, a level of teamwork on the flight deck which was also inappropriate. The response to some marginal weather conditions by the aircraft commander was sloppy - but by then we see him exhibiting the signs of (inevitable) fatigue. This wouldn't have mattered if it had been the usual straight-in approach to land off the ILS - which of course it usually is….

they missed. The controller had adopted an unprofessional attitude to his fitness to commence duty comparable to that of the commuting captain.

There is another player on the fringe here too, the **Investigator**. Since our case study ends with the investigation, it is also worth acknowledging that collecting meaningful evidence about off duty activities prior to an incident on duty can be difficult, especially if the relevant circumstances are other than the simple matter of commuting. Perhaps for that reason, it has often been overlooked (or, as in this case, been the subject of cursory leading questions during the interview) unless a fatal accident is being investigated with the greater rigour with which such investigations are usually prosecuted.

Finally, before I offer my recommendation, please remember where I started out. Whilst the actions and attitudes of every professional pilot and control-

RECOMMENDATION:

Just one? It's a difficult call with so many of the theoretical defensive barriers compromised. But given that the ultimate responsibility of an airliner captain for the safety of their aircraft is exercised as an agent of their employer who determines the selection to and support for this role, I will go for a one-off external assessment of the overall safety of flight operations at the airline. The results of this will need to be taken seriously by the airline's general management who will need to sanction the changes in corporate priorities and operational process that are likely to be needed. Almost all professional pilots (and controllers) and their managers are 'can-do' people and they need to be both carefully appointed and then appropriately managed. This Case Study has strongly suggested institutional weakness as much as individual failings – and the ANSP involved is not far behind the airline in my assessment.

Cross-country skiing in Norway
– don't jump to conclusions!

Every year, kids in Norway get a week off school in February, known as "winter holiday".

I am definitely one of those who has learned to appreciate this break, a whole week "offline", spending time in the Norwegian mountains skiing or just relaxing, enjoying reading a book. A couple of years ago I was at one of my favourite winter resorts in Norway. This particular day we went out for a longer than normal cross-country skiing trip, the weather was bright and sunny, but windy and freezing cold which made it difficult to keep a conversation going. Not talking makes you sometimes even more focussed on and amazed by the beauty of the nature, - as I said, totally "offline". The skiing track was clearly marked with wooden poles, easy to follow. Suddenly, though, as we reached a fork in the track we realised they were no longer there. The track divided itself into two, one to the left, slightly downhill, the other straight ahead but on more of an incline, but which should we take? We'd left the piste map behind in the chalet, after all we knew these tracks like the back of our hand, didn't we? So without too much thought we just jumped to the conclusion that it had to be the left one, downhill; our starting point was in the valley so it had to be the one leading us

back to where we started, right? After a while we were lost…Why am I telling you this? Well, read the rest of the story and you will understand.

When returning to civilization 3 – 4 hours later, I checked my mobile and noticed a missed call - it was my safety manager calling me back to reality. Normally she would never disturb me when I'm away, so I knew it had to be something serious. It was. An Airbus 320, a passenger flight, had carried out a departure from a taxiway! I could hardly believe what I heard – how could that be possible? Lots of questions passed through my mind. The available take-off-distance on the taxiway was estimated to be about 1500m – luckily the departure had gone well, and there was no damage whatsoever.

Something rather interesting happened midway through the conversation with my safety manager, which I really regret to admit. I was eager to know the name of the airline involved – wow! This information certainly made sense. Of course it had to be that airline – "no one else would depart from a taxiway"….

I will not go through what the incident report concluded, nor tell you about all the recommendations or airport mitigations; instead, I will try to put you in the seat of the pilot and in the position of the controller involved. This is by no means an attempt to reconstruct the event. Rather I'm trying to highlight one particular aspect of human nature that is not necessarily a good one for those of us involved in safety – how tempting it is to jump to conclusions without knowing all the facts.

The aircraft was taxiing out for departure; traffic was low and the frequency very quiet. On the flight deck there were three pilots: the captain (flying), the first officer on training, plus an extra pilot monitoring him. They were behind schedule, discussed the situation amongst themselves and decided to request an intersection departure. They received clearance to the intersection, and shortly afterwards ATC passed them the departure clearance; the captain exchanged the aerodrome chart describing the taxiway system for the one describing the airborne departure route. The captain turned the aircraft to the right towards the intersection, carefully looking to the right and monitoring the taxiway line partly covered by some snow and ice patches. He continued to the right, making a full 180 degree turn. This was what he saw ahead of him.

The crew performed the standard procedures for take off and increased the power, started the roll and got airborne. When airborne they received a call from the controller, "you just departed from a taxiway". "What?", the captain thought. He hadn't noticed

anything abnormal; none of them on the flight deck had.

The controller received a request for an intersection departure. This airline hardly ever requested that, why challenge the flight crew? They must know what they are doing, right? After checking the area for vehicles and incoming aircraft (i.e. none), he issued the departure clearance. Job done, he turned around busy with something else. The aircraft had read back the departure clearance correctly and was on its way to the intersection. After some time he turned around only to see the aircraft rolling down the taxiway parallel to the runway. Fractions of a second: to abort or not to abort? He decided not to intervene; the aircraft got airborne 400 metres before the end of the taxiway.

Below is a photo from the runway, this clearly shows how the runway and the taxiway look similar from the intersection. The pictures were taken only a couple of days after the incident occurred: same weather, visibility and time of day.

I began to include this incident as a case study when giving presentations in my company. I started with a slide showing the headline news as covered in the media, which focused on – yes, you've guessed it, the aircraft operator. I then asked the audience the following questions: "What are you thinking now?", "What is your reaction to these headlines?" I always got the same answer, every time, no matter who was in the audience: management, staff or ops people. We all shared the prejudiced attitude, like it or not. Then I showed the photos of the runway and the taxiway and asked "Can you spot the difference?" Most of the time, the photos were greeted with a knowing silence.

After experiencing and feeling a bit guilty about my own weakness in jumping to conclusions, I realised that my reaction was not at all unique. It worries me that my colleagues and I so easily jumped to the incorrect conclusion without knowing all the facts. How are we supposed to learn if we don't base our decisions on the truth?

So what is all this telling us? Well, firstly we need to be aware and prepared for what we think will never ever happen. It usually does. Second, as investigators we need to put away any

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prejudice and/or preconceived ideas and deal with the reality. Lastly, as intelligent people and operators, who are trained to make quick decisions, we have to understand that our strong sides sometimes work against us, that quick decisions are sometimes made too fast, that if we do not take our time and cross-check, this can result in our jumping to the wrong conclusions.

Incidentally, after an hour or so of further skiing we did find the correct way back to our starting point, but it would have been so much quicker and easier if we had taken the map and gone straight ahead.

Sleep and fatigue

By Alberto Iovino

Many studies agree on the fact that an adult human would normally need 7 to 9 hours sleep a day; moreover, such sleep should be of a "good quality", which means uninterrupted and including both deep and REM phases.

Alberto Iovino

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He was an airline employee for 8 yrs (PAN AM and Delta at Fiumicino – passenger service, ramp/operations; FAA licensed aircraft dispatcher) and worked for 13 years as ATCO.

centage of their lifetime can be truly assessed as being more fun than a good nap.

(Modern) life goes on though, and never mind your circadian rhythms, you have to cope with the necessity of being awake when, and for as long as, your multiple engagements require. We as humans passed through many centuries harmonising our internal

fun or work, necessity or pleasure, we squeeze our sleeping time like an extra tank to exploit when the rest runs empty. In my day I used to go out; now, we have just had our second daughter, and the authoritative newcomer loudly fills with her sweet, drilling voice most of the intervals between each feed and the next, so we split our night time duties. Though I am not an operational controller any more, my

I somehow always felt my biological needs to be much higher, just to find myself struggling every morning since schooldays to achieve what our ancestors did over thousands of years, i.e. to (re)gain an upright position.

Troubles of that kind are evidently obscure to people (there's my wife) who wake up ahead of their alarm clock. I honestly never envied them, and to those who believe that sleeping is wasted time I would suggest stopping for a second to reconsider what per-

clocks with the rising and dawning of the sun above us, and even getting your tenth child under way couldn't do much to keep you up all night; then electricity, the most dramatic change in history, allowed the colonisation of the night (by far the greatest of its kind, with no offence to Columbus or James Cook), and since then things have never been the same.

So we stay up. And we feel maybe a little tired, but happy, because our conscious life gets longer. Be it for

wife still is and, once her leave of absence is over, we will have to rearrange our schedule.

And here we come to the point: what happens to those seven-to-nine sleeping hours, and what happens to us, once they are gone? The answer is composite, and somehow subjective, but possibly less than one would think.

There is a wide range of literature on the subject, variously addressed using a scientific, medical, sociological, eco-

nomic, labour-relational and sometimes commercial (people selling mattresses and sleeping pills) approach. A nice publication by EUROCONTROL[1], fifty-two ATC-oriented pages on fatigue and sleep management, is easy to read, useful and definitely recommended.

The general idea is that setting our life rhythms to match our internal circadian clock would be good for our health and best for our performance; so far, so obvious. By the way, the so-called circadian clock in humans is a function of the hypothalamus, which controls the secretion of melatonin and the body temperature. That means, and do forgive me for making it so simple (please refer to better

The issue with sleep and fatigue is therefore twofold: it is a matter of regularity and quantity/quality.

experienced when trying to recover from jet lag after a long east-west or west-east journey. So, while you can stay awake by keeping yourself busy and uncomfortable (rule number one of the perfect sentry), in a well lighted environment, your clock still tends to encourage you to sleep when it believes it is time to do so.

tent manner. This is an important concern, and it should not be sacrificed too lightheartedly to other needs.

Apart from any considerations about personal health, the fact is that fatigued people are often very poor judges of their own alertness levels. This is not about generically feeling tired, rather on failing to respond to information, losing short-term memory and situational awareness, and so on, up to experiencing microsleeps, i.e. "episodes of total perceptual disengagement from the environment". Self determining whether you are too tired to work is a complex task, with consequences which also shift into ethics (as you are asked to consider elsewhere in this issue of Hindsight); neglecting

sources for something much more accurate), that every day we anesthetise ourselves to get the rest without which, in the long run, we could not survive.

The word "circadian" comes from Latin, meaning "approximately one day" – in fact, a complete cycle of the circadian clock lasts approximately 24 hours. The clock can be influenced by external factors such as light, but, being rhythmic, it also tends to be resistant to change, as many will have

The issue with sleep and fatigue is therefore twofold: it is a matter of regularity and quantity/quality.

Air traffic controllers work shifts, so they have to give up their sleeping regularity for their entire operational life; we will not discuss this here, but it is undeniably a significant personal price that every controller pays in his/her job. Nevertheless, there are ways to counteract such a situation, and in any event provide oneself with enough good sleep in a fairly consis-

to avoid habits which would make it most likely to happen hardly makes sense.

Back to trivialities and, just as a domestic example, one night after a few weeks of systematic sleep deprivation, I was preparing some extra milk for the baby, in addition to that provided by her mother. As those who have children may know, it is a quite simple sequence of actions: take a feeding bottle from the steriliser; pour some water into the feeding bottle, determining

1- "Fatigue and Sleep Management – Personal strategies for decreasing the effects of fatigue in air traffic control", DAS/HUM Eurocontrol 2005

Sleep and fatigue (cont'd)
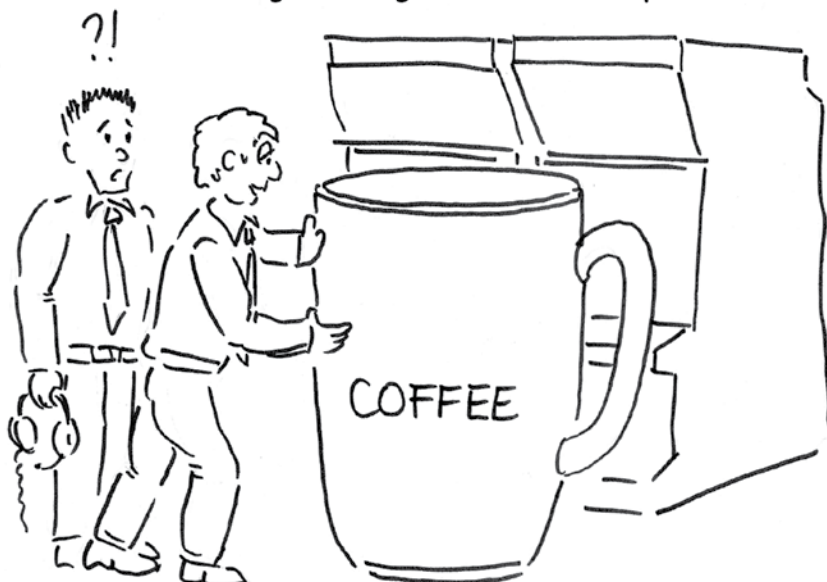
Fatigue management is for wimps!

the exact quantity from the graded scale; pour the water into a milk pan, warm it up and pour it back into the feeding bottle; add the powdered infant milk, close the bottle, shake it up and cool it down. After duly complying with steps one and two, I found myself anticipating step four, thus dropping the milk powder into 40 ml of cold water. While dumping the unusable stinky mud into the sink and taking another bottle from the steriliser, I started fancying about what the proper amount would be in case of no availability of any mother's milk, just to realise a moment later that I was warming up an unreasonable 120 ml of water. From that point I got back on track, but the idea of an equivalent experience in an ops room, when handling traffic in a couple of combined sectors, is one that does not make you feel at ease.

Some more instances, why not in the transport field?

In June 1995, early in the morning, the Danish-owned vessel Svendborg Guardian ran aground on sand off the north Queensland coast. Among the Australian Transport Safety Bureau (ATSB) findings regarding the contributory factors, it was noted that "there was nobody on the bridge for a period of almost five hours with the ship effectively out of control. The bridge was unmanned because the Second Mate left the bridge shortly after 0105 and failed to return because he fell asleep. The Second Mate was suffering from extreme fatigue as

a result of poor quality sleep from 18 June to 23 June and his decision not to sleep after the ship left Townsville. This decision [was allegedly] prompted by his desire to watch a rugby league match".

Up in the air, and once more from the ATSB, a pilot on a single-crew night freight flight carrying newspapers put his aircraft on a wrong track on departure and, after levelling off at the cruising altitude, fell asleep. When he realised it was time for descent, he started setting frequencies of the (supposedly) relevant navigation aids, but could not get any directional information. After wandering for a while, he landed the aircraft on a dry salt lake, luckily with minor damage and no injury, and was subsequently located through the ELT, about 200 miles off his destination. The pilot "… had had three full days off prior to signing on late in the evening of the day before the accident. He stated that he normally tried to sleep in on the morning before the night shift, and then get a couple of hours sleep in the afternoon. However, on the morning before he signed on for the night flight he was unable to sleep in and was then also unable to sleep in the afternoon. Consequently, by the time he signed on for the flight, the pilot had been awake for approximately 13.5 hours. It is probable that the pilot's lack of sleep prior to signing on for the flight resulted in an increased level of fatigue".

Now, let's not think this is an Australian issue only. As a fact, records of pilots and air traffic controllers experiencing sleep-and-fatigue problems exist in many other countries, and you can probably think of your own examples. While pilots often refer to sleeping problems linked to travelling through time zones and sleeping in noisy and poorly air conditioned hotel rooms, both pilots and air traffic controllers sometimes blame the way shifts are organised and managed.

In ATC, besides the extreme stage of actually falling asleep (and beware of microsleeps), the various stages of performance impairment are probably the real concern. An approach controller reported to the NASA Aviation Safety Reporting System that two aircraft had passed about one mile from each other after he misinterpreted the briefing from the colleague he had just relieved, as involving a procedure turn whereas a straight-in was expected. The reporter said that he had been having sleep difficulties linked to a period of shift changes and that "I was on about the third day of 4 or less hours of sleep".

If rostering does not take into account the physiological need for rest, that's a subject to keep on addressing. But personal behaviours in the framework of the existing roster indeed rest in everybody's own hands. So wake up folks, and don't give up on either hope or sleep.

Dying for a rest:
how much of a problem is fatigue?

By Anne Isaac

Just after midnight on 24 March 1989, the single-hulled Exxon Valdez struck Bligh Reef off Alaska's southern coast. The tanker spilt 11 million US gallons of crude oil into the sea. The slick eventually covered 11 million square miles of ocean; hundreds of thousands of sea creatures died. Within two years, the local marine population and fishing industry had all but collapsed. Several residents, including a former mayor, committed suicide and the Alaska Native Corporation went bankrupt. Billions of dollars were paid in damages and fines. At the time of the accident, there were two crew members on the bridge. The third mate, then aged 25, was in charge of the wheelhouse and an able seaman was at the helm. Neither had been given their mandatory six hours off duty before their 12-hour duty began. Amongst its main findings, the US National Transportation Safety Bureau's (NTSB) accident investigators concluded that the Exxon Shipping Company's manning policies "did not adequately consider the increase in workload caused by reduced manning". The widely-shared belief that fatigue played a significant part in marine incidents had been made official. Yet, despite that unambiguous finding more than 20 years ago, the issues of reduced manning, increased workload and resulting fatigue have continued to play a major role in many transport accidents to the present day.

This event is not unique in the history of accidents involving loss of life. The Bhopal disaster, the Herald of Free Enterprise, the Challenger accident and the runway catastrophes at Tenerife and Linate all have strong factual evidence of fatigue, indicating the presence of poor decision-making leading to impaired operator activity with disastrous consequences. However, the issues of fatigue, shift work and sleep deprivation are poorly understood and a social phenomenon that is 'unpopular' at best and 'ignored' at worst by investigators and safety specialists since, in all these professional environments, the operational staff are considered highly trained, extremely competent and have a well developed sense of 'duty of care' towards their safety responsibilities.

Are there similar issues in the ATM environment? The short answer is yes. So what important points should we consider in the debate regarding fatigue? The main factors are concerned with the nature of fatigue, the issues of shift work and the inevitable consequences of sleep deprivation for specialists who work in a 24/7 environment.

What causes fatigue?

People get tired when they have been awake too long. Humans naturally tend to fall asleep or suffer from extreme fatigue between 2am - 3am. But how long is 'too long'? The harder people work, the sooner

Dying for a rest!: how much of a problem is fatigue? (cont'd)

they need time to recover. Workload itself is influenced by the design of the work, the equipment and procedures people must use and the expertise they have acquired through training and experience. In fact, the problem of workload and its measurement is a little more complicated than it appears at first sight. This is because it is the result of a mix of external and subjective factors. So why is workload a tricky problem? The main issue is associated with its definition, since there is little agreement on what workload actually is. Some researchers focus on the external demands of a working situation, whilst others concentrate on the person's experience of workload. Additionally, no clear relationships have been found between measures of external demand, subjective assessment and physiological indications of workload. The weight of demand a person can cope with is one focus for workload but another focus has to do with the pattern of demands. For example, talking on a mobile phone while driving a car is not

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Being distracted or having to switch tasks occupies more of our attention and memory and increases the risk of making a mistake.

generally considered to be a weighty workload task, but all the evidence points to the greatly increased risk of an accident; but being distracted or having to switch tasks occupies more of our attention and memory and increases the risk of making a mistake. The introduction of technology into both the flight-deck and the ATM environment will have inevitable consequences on the stress and fatigue experienced, particularly in training.

There is also the issue at the other end of the spectrum, namely having too little to do which can equally put safety at risk since boredom and monotony are as fatiguing as heavy workload. The bottom line is that a person's experience of workload is a combination of both the actual external demands of the job and the individual characteristics and expertise of the person doing the work.

What are the effects of fatigue in the operational environment?

The main effects of fatigue on people at work are psychological. Accident records show that the mental effects of fatigue on the individual can readily translate into catastrophic physical events, affecting individuals, their teams and the wider organisation. The most potentially damaging effects of fatigue are inattention, and the fact
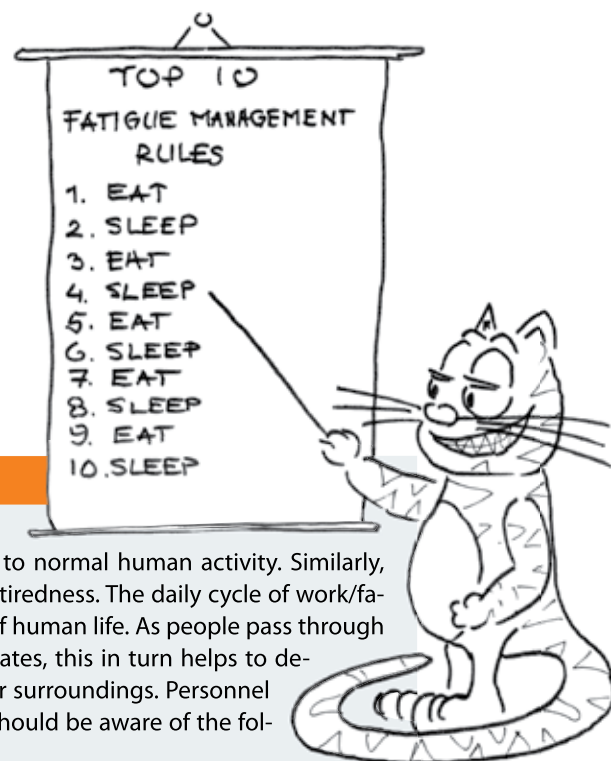
that fatigued people often fail to acknowledge that their performance – both their own and that of others – is being degraded.

Key skills and behaviours affected by fatigue:

- **Slower information processing and degraded mental performance:** taking increasingly longer to transform data or process information; including confusion, poor concentration, narrowed perception and forgetfulness which leads to degraded vigilance and poor response to changing situations.
- **Faulty memory recall of recent events:** for example, the content of a radio message may be immediately forgotten or recalled incorrectly.
- **Omissions and carelessness:** people increasingly skip steps, miss checks and make mistakes.

- **Slower comprehension and learning:** it takes longer and longer to understand any written or spoken information, or display patterns, e.g. a map or charts.
- **Worsening team performance:** this includes decreased interaction with crew/team members and degraded communication due to lower sensitivity to other people's needs and aims. People may become moody, irritable, argumentative or socially withdrawn, all of which can badly affect team relations.
- **Diminished personal safety:** reduced self- and situation awareness leading to apathy, neglect of normal safety precautions, and more risk taking.
- **Impaired leadership:** some people take longer to make decisions while others make poorer ones; the people themselves are often unaware of the decline.

Fatigue management

Fatigue is a normal human response to normal human activity. Similarly, sleep is a normal human response to tiredness. The daily cycle of work/fatigue/sleep is a normal, healthy part of human life. As people pass through this cycle, their level of arousal fluctuates, this in turn helps to determine how alert they can be to their surroundings. Personnel working in an aviation environment should be aware of the following fatigue management issues:

- **Perceived risk or interest: I**f people are stimulated by their sense of risk or interest in what they are doing, they can stay awake and alert for longer. However, the time they then need to recover from sustained activity will also get longer. If people are engaged on tedious or boring tasks, they will feel tired sooner.

- **Environment:** People become more fatigued in environments with bad levels of light, noise, vibration, temperature and motion.
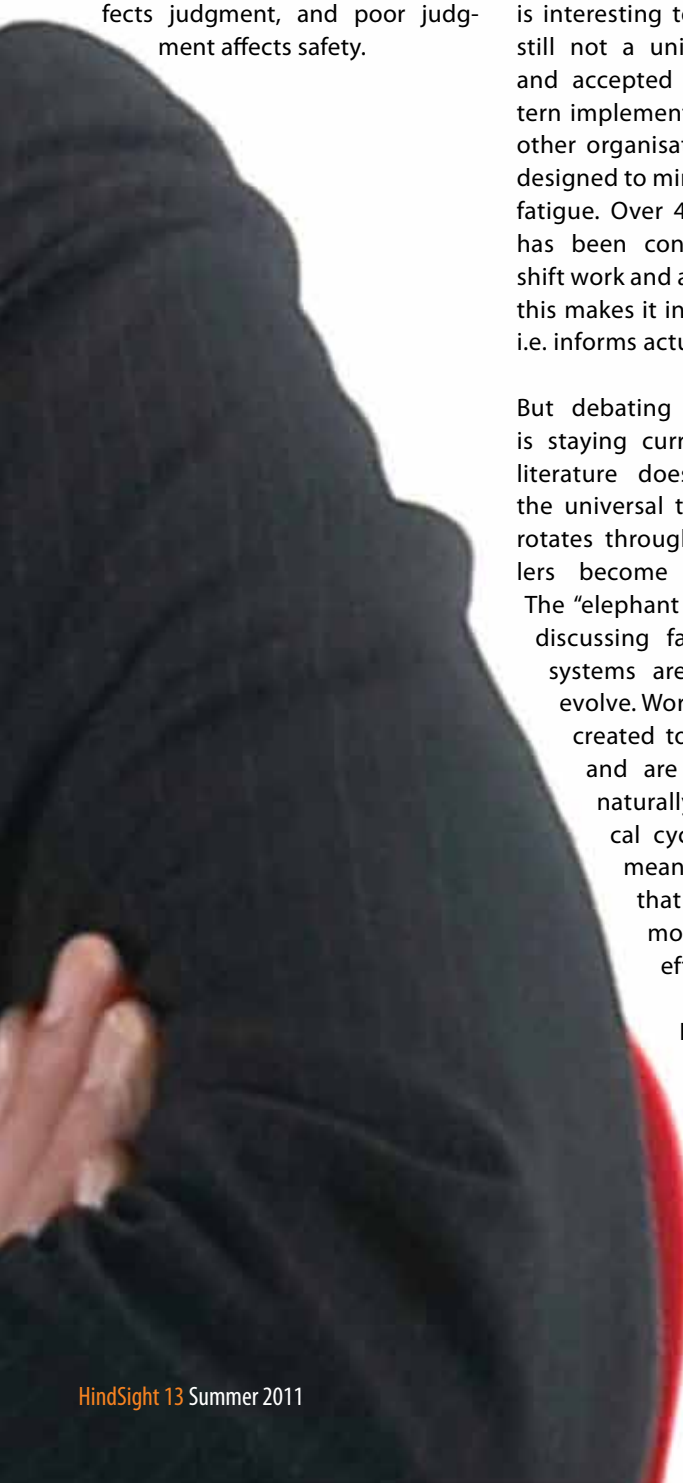
- **Time of day:** People live by a natural daily rhythm, which means that they feel least alert in the small hours of the morning and most alert in the period before midday.

- **Fitness and exercise:** People who are overweight and/or lacking in exercise will tend to feel fatigued earlier than their leaner, fitter or more active colleagues.

- **Food and diet:** Inadequate levels of nutrition accelerate the onset of fatigue. Different foods also affect alertness. For example, heavier meals dominated by carbohydrates encourage sleepiness, while lighter, protein-based meals encourage wakeful alertness.

Food is a powerful fatigue management tool. Fatigue levels may be partly controlled by what you eat and when. Here are some key tips:

- Meals made up largely of carbohydrates facilitate better sleep
- Meals made up largely of protein assist wakefulness and activity
- Regular meal timings help to regulate the human 24-hour cycle
- On night duty, main meals should be eaten before 01.00 hrs
- After night duty, a light snack of carbohydrates should be taken no later than two hours before expected sleep time
- Drinking alcohol before sleep is a bad idea – it may help you to 'drop off', but shortens the deep sleep you really need
- Taking caffeine within 4 hours of sleep is likely to disrupt the sleep you get. But it can assist nap recovery.

- **Length and quality of sleep:** People need adequate time to sleep and good recovery demands that the sleep itself is of good quality. 'Sleep debt' is an insidious product of disrupted and poor quality rest and is often identified as a contextual factor in occurrences.

I know when I'm tired!

By Andy Kilner and Nuno Cebola

We expect to be able to watch TV at two in the morning, we expect that when the light switch is flicked, a light comes on at midnight, midday or four a.m. and we expect to be able to take a red-eye flight through the night and someone to be there to control it! We have an expectation of a 24-hour existence and have created shift working to deal with it...

Unfortunately, as a biological organism, we have not really been designed for a 24-hour existence. No matter how we try to change the way we work, the basic truth is that we are programmed to a circadian rhythm that means working shifts comes with the burden that is fatigue. Fatigue affects judgment, and poor judgment affects safety.

In a great deal of academic (scientific) literature, the cause of fatigue is laid squarely at the feet of the shift system, and its interaction or interference with the natural sleep/wake cycle. When considering shift work (in ATM, aviation, and other safety-critical disciplines), it is interesting to note that there is still not a universally recognised and accepted standard shift pattern implemented across ANSPs or other organisations that has been designed to minimise the impact of fatigue. Over 40 years of research has been conducted into sleep, shift work and alertness, yet little of this makes it into the applied field, i.e. informs actual shift patterns.

But debating whether an ANSP is staying current with academic literature doesn't really address the universal truth that as a shift rotates through its cycle, controllers become increasingly tired. The "elephant in the room" when discussing fatigue is that shift systems aren't designed, they evolve. Working times are often created to fit traffic patterns, and are not optimised for naturally occurring biological cycles. Ultimately this means we accept shifts that we know make us more vulnerable to the effects of fatigue.

Further, whilst the shift itself is tiring, even if the rotation is "optimally designed" there are additional disturbances that compound the

rest opportunities associated with working shifts. Babies crying, neighbours doing maintenance, somebody with a car that won't start, all of these things compound the fatigue that is already built into the shift system. As we look at these disturbances, we should ask ourselves how responsible is the organisation for addressing them and accounting for them in work patterns?

In a great deal of academic (scientific) literature, the cause of fatigue is laid squarely at the feet of the shift system, and its interaction or interference with the natural sleep/wake cycle.

The organisation will organise the shift rota to provide a suitable break between shift rotations, and there is even legislation in several countries to stipulate how this should be administered. But that system cannot account for additional idiosyncratic sources of disturbance that are present in all our lives. What then – in fatigue terms – does a measure of shift-induced fatigue have to account for and what can we apply from the literature in a pragmatic way to help address fatigue?

I know when I'm tired (cont'd)

In a recent study of fatigue in ATM [Cebola, N., Proceedings of the IEHF Conference 2010], four factors emerge consistently from the literature. It would be excellent to say that four factors emerged from the literature with respect to ATM, but the majority of publications focussing on aviation are concerned with flight crew; very few focus on ATM. The four, industry-wide, factors can be summarised as:

■ The position in shift rotation (days, nights, earlies, etc.) and amount of time on duty since starting work. It is well known that the "graveyard shift" coincides almost perfectly with the major dip in the circadian rhythm associated with sleep.

■ Cumulative sleep debt built up over the course of the shift rotation. Shift systems are nominally designed so that controllers have the opportunity to recover (rest days, etc.) before beginning the next shift cycle. However, it's not always clear that controllers are able to sleep fully between cycles despite their rotation allowing for it. Controllers still have social lives, young children and relationships that must be managed during non-work periods, periods when sometimes they should be sleeping. Cumulative sleep debt can only be cured by more sleep. It is interesting that academic literature mentions sleep debt commencing when less than 8.25 hours of sleep per night are achieved!

■ The quality of sleep during the shift rotation. Even if we get enough sleep, if it is disturbed, or broken, or we sleep badly because, for example, it's too hot, then this will not help us to recover effectively from fatigue. Our sleep debt continues to grow despite getting what we think of as a full night's sleep.

■ The impact of "napping". Where the ability to nap at work is available, a rest of 20 minutes is highly effective at reducing fatigue levels. But longer than 20 minutes and a "nap" rapidly progresses to sleep, and this can cause more fatigue. Some ANSPs are also unwilling to support the concept of controllers "sleeping on the job", and rest-rooms with TVs replace areas to "nap". This removes completely the opportunity for recovery.

These four factors all combine to provide us with a cumulative experience of fatigue. Unfortunately, how they combine has never been fully explained. No single model of fatigue accounts fully for the interactions, or explains them to any significant depth.
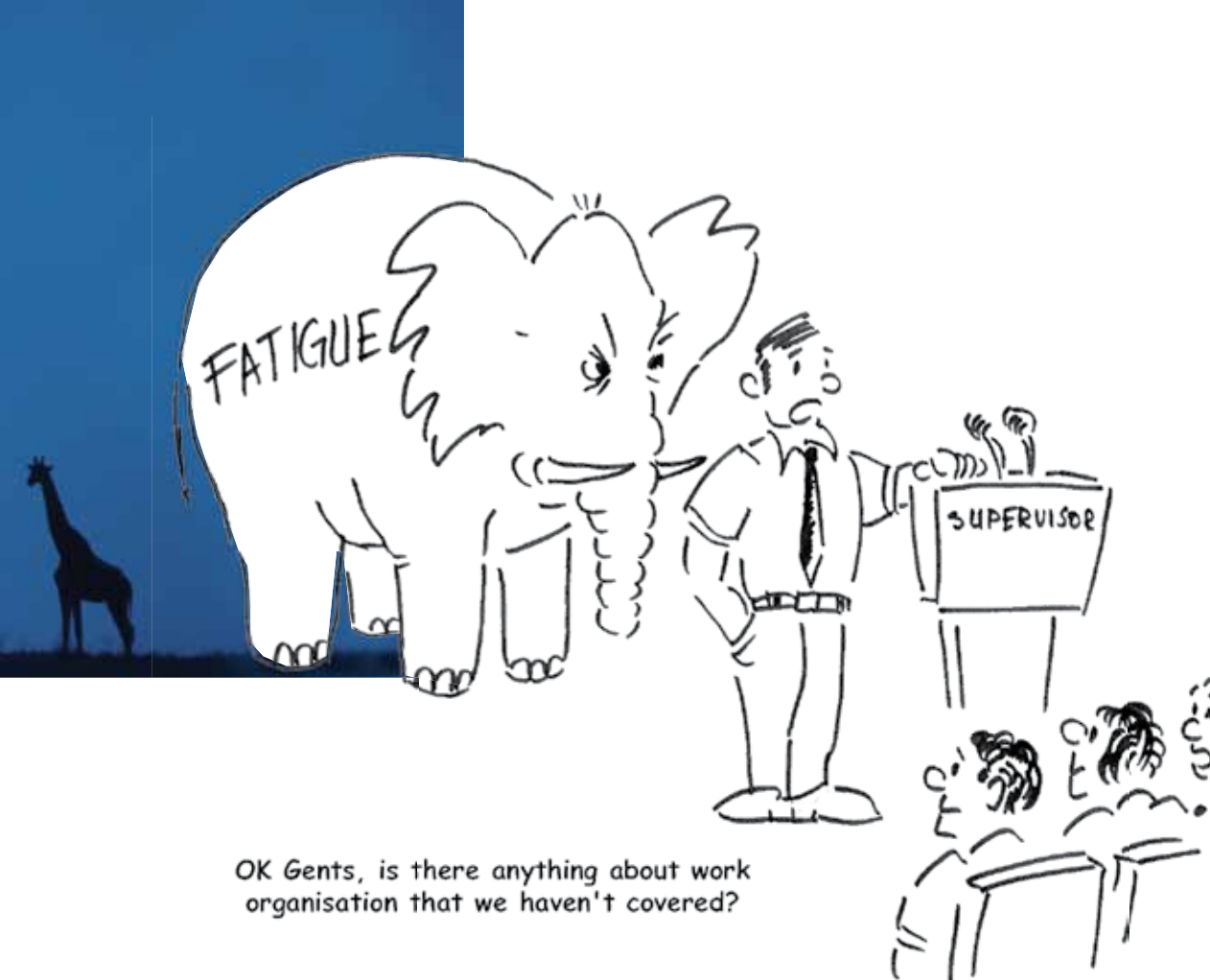
It is possible, therefore, to have excellent papers on the impact of shift work on fatigue and predictive measures of fatigue based on position in the shift rotation. These however don't take account of sleep debt, or quality of sleep. There are excellent papers on the restorative nature of "napping" during night shifts and the impact on vigilance, but again these are not linked back to a fundamental underlying measure of fatigue and the shift.

We are left in a position of trying to extrapolate relationships between poorly defined variables and providing concrete answers for the operational community. And we should not forget the operational community. Each controller and engineer working shifts has a personal experience of fatigue, and will tell stories of colleagues in "other centres" who have fallen asleep on duty. These anecdotes are also likely to be followed by the statement, "I know when I am tired". We risk confirming the operational perspective that we can't tell them anything they don't know, partly because the research isn't there, but also because we are all "experts" at fatigue given that we all get tired.

This leads us on to the "true-ism" of fatigue - "we know when we are tired" - yes we do! The literature makes it clear [Gordon & Straussberger, Low vigilance in Air Traffic Management, EUROCONTROL 2006] that we do know when we are tired. What it also makes very clear is that we have no real concept of just how badly our decision-making (controlling) is affected when we are fatigued.

But all is not lost. Very interesting work has been undertaken by Imperial College London [http://www.geomatics.cv.imperial.ac.uk/html/research/atc.asp] and presented at the EUROCONTROL Safety and Hu-

OK Gents, is there anything about work organisation that we haven't covered?

man Performance Sub Group. Dr Majumdar of Imperial has taken a first principles approach to understanding and assessing fatigue, but even he admits that he does not have all the answers. Basic questions that were identified by Imperial (and are being addressed), included:

- If we measure alertness (almost the opposite of fatigue), then what is a "poor" level of alertness? This provides us with slightly different views of the same problem, e.g. is it fatigue, or are we suffering from a lack of alertness? Is being cold the same as not being warm?

- Can we make concrete operational decisions about fatigue, can we provide relief for controllers suffering from fatigue (or a lack of alertness), in the same way as for someone who is sick?

Whilst fatigue is a problem even older than shift work, it seems as though there are still fundamental questions to be answered before we can get a good working model

that allows us to make valid predictions about attention and the likely risk of impaired judgment. There are a range of "fatigue models" on the market that purport to provide you with some of the answers but before you rush out to try one, think carefully before investing:

- What are they actually measuring and is it what we need?
- How have they been validated or demonstrated to be "accurate"?
- Have they been designed for ATM or the cockpit?
- Do they account for the four factors of fatigue?

Most importantly, think very carefully about what you are going to do when you get the answers and whether measuring fatigue will actually enable you to discuss the "elephant in the room". A shift system that causes fatigue, but gives controllers plenty of time off and good pay, is likely to be defended strongly. And finally, no matter how well fatigue is measured, we will still be addressing the symptoms, not the causes.

Andy Kilner

has been working in the field of human performance in complex safety critical industries for over 20 years. Andy started working in ATM in 1993 at NATS, he worked on civil nuclear, nuclear defence, conventional defence and ATM projects. He joined EUROCONTROL in 2009 and has been supporting the ESP+ Safety Culture Programme and more recently SESAR.

Nuno Cebola

was awarded a BSc in Psychology and continued his studies with an Masters Degree at the Instituto Universitário de Lisboa. Nuno completed an internship at EUROCONTROL in 2009 where he researched the impact of fatigue on performance and began the process of determining whether a fatigue index could be developed for ATM. After his internship Nuno began a PhD in the Human Factors Research Group at The University of Nottingham.

Is controller fatigue as big a problem as pilot fatigue?

By Gérard van Es

It is well known that pilot fatigue can present a risk to flight safety. Different numbers have been published on the share of the pilot fatigue in aircraft accidents. For instance, it is often claimed that pilot fatigue contributes to 15-20% of fatal aviation accidents caused by human error. Other sources have indicated lower numbers in the order of 1-2%.

It is not easy to determine whether pilot fatigue played a role, especially if the pilots didn't survive the accident. What about controller fatigue? Although controllers are not faced with jetlag, noisy hotels, long flights, etc., fatigue can play a role in their performance. Sleep during the daytime is usually not as effective as during the night, which can affect the controller who has to work during the night or very early in the morning. Also a lack of sleep can affect the controller's performance. A query in the NLR-ATSI air safety database failed to provide an enormous list of accidents in which controller fatigue played a role. One should keep in mind that this result could be biased by the fact that controller fatigue is not always recognised by the investigators or even considered as a possible factor. Let us consider two interesting examples in which controller fatigue was a factor.

Gérard van Es

works as a Senior Advisor flight safety and operations for the NLR-Air Transport Safety Institute - Amsterdam, the Netherlands. He is currently involved in the European working group for the prevention of runway excursions.

CASE 1 (reference: NTSB report LAX04IA302)

On August 19, 2004, a Boeing 747-400 overflew a Boeing 737-700 while the B737 was on the active runway 24L, at Los Angeles International Airport. The Boeing 747 came within 200 feet of the B737 while it was executing a go-around on runway 24L. The B737 had been cleared for takeoff on runway 24L. At the time of the incident, a controller change on the LC2 position had just occurred and the relief controller was responsible for handling both aircraft. The Safety Board concluded that a loss of separation between the B737 and the B747 was caused by the LC2 relief controller's failure to appropriately monitor the operation and recognise a developing traffic conflict. The investigation determined that the relief controller had had only 8 hours off duty between the end of his August 18 evening shift at 2330 and the beginning of his morning shift at 0730 on the day of the accident. As a result, the relief controller reported sleeping just "5 or 6 hours" the night before the occurrence. The controller described his shift leading up to the occurrence as a "hard day." The investigators
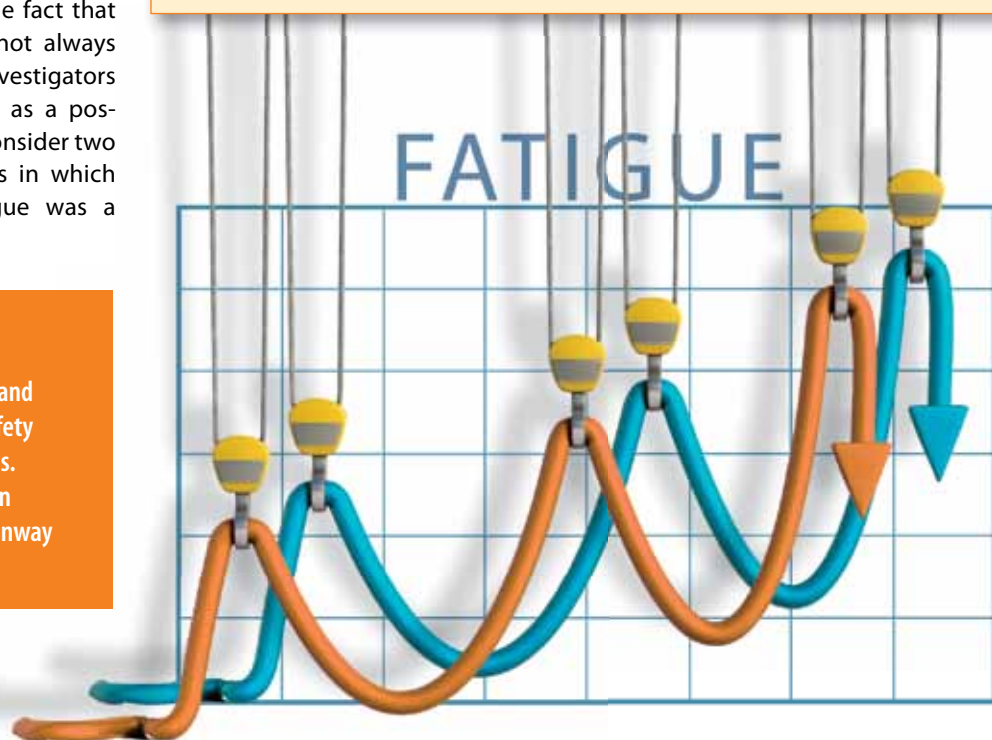
CASE 2 (reference: Russian state investigation)

A TU-154 aircraft was destroyed by impact and a post-impact fire when it collided with vehicles on the runway during a landing at Omsk on October 11, 1984. The accident happened in darkness and in poor

concluded that the acute sleep loss resulted in a slight decrease in cognitive performance of tasks involving working memory and reaction time. Research on sleep and human performance points to an optimal sleep length of between 8 and 9 hours per night. Studies conducted under controlled laboratory conditions have found that restricting sleep to 4-6 hours for one night causes moderate increases in subjective sleepiness and slight decreases in cognitive performance of tasks involving working memory and reaction time.

weather with a 100 m cloudbase and visibility of 3 km in mist and rain. The aircraft was operating a scheduled service from Krasnodar to Novosibirsk via Omsk. Just before the landing the airport ground maintenance crew had requested permission to dry the runway. The tower/ground controller on duty gave the permission and fell asleep right after doing so. He had also forgotten to switch on the "runway occupied" warning. The ground maintenance crew on the runway saw the landing lights switched on. They contacted the tower/ground controller three times but received no response (he was asleep). After that they ignored the lights, thinking they were being tested.

When on final approach, the pilots asked the approach controller for clearance to land but got no response. However, after a second request the flight was cleared to land. The approach controller had verified the runway status as unoccupied and had also tried to contact the tower/ground controller but received no response as this person was asleep. He then contacted the ground controller on an internal radio and received an inaudible reply which the approach controller interpreted as "free", meaning the runway is free. The approach controller then cleared the flight for landing. After passing the inner marker, the captain thought he could see something on the runway and asked 'what's there on the runway?'. The navigator also thought he saw something and replied 'something's blinking'. However, the approach was continued and the aircraft touched down normally. Immediately after touchdown the crew noticed that there was indeed something on the runway and shortly after that realised that the runway was obstructed by a number of vehicles. Two sweeper vehicles and an escort car were on the runway. The pilot immediately attempted to take avoiding action by steering the aircraft towards the right but without success and the aircraft collided with the vehicles. The impact and post-impact fire caused many fatalities amongst the passengers, crew and people working in the ground vehicles.

The investigation found that one of the causes of the accident was a lack of co-ordination between the tower/ground controller and the approach controller. The tower/ground controller had fallen asleep and therefore failed to tell the approach controller that the runway was obstructed. He had allowed the service trucks to move onto the runway without permission from a supervisor. He had also forgotten to switch on the "runway occupied" warning. After the accident he could not remember any of his actions during that time. He was supposedly suffering from lack of sleep because of his young children. This might explain the fact that he fell asleep and was also violating procedures at the time of the accident.

Although controller fatigue does not appear to have contributed to as many accidents as pilot fatigue, these examples show that controller fatigue can result in serious events.

CONTROLLERS
PILOTS

In the zone

By Keith Cartmale and Ellen Beckers

'Wow, that was f****** brilliant!'. 'We managed to cope with everything that was thrown at us, and more!' 'You're not kidding, it was hellishly busy, but we were cooking on gas! I thought we could have been in trouble when the TRA was opened at short notice, especially with that Guppy doing his usual thing, requesting a level he can never achieve, then taking half a year to reach the level we knew was realistic' 'You're right, it could have been a problem, but I was anticipating it, I kinda just knew it was going to happen, so had a plan B… I'm sure it was because we were working so well together'.

This is an exaggerated example of a conversation controllers could have when they have just put in one of those special shifts, one where everything went well, where they were able to anticipate and manage those quirks and issues that often appear: the pilot who is slow to respond; the pilots that you have to keep repeating messages to; the frequency outage/interference; the high traffic levels followed by dips then rapid increases again; the emergency descent, the colleague(s) who is not quite with it.

In sports circles, this kind of skill and being able to apply it is known as being "In the Zone". It's about being able to do the right things, at the right time, with consummate ease, whilst being ultra efficient yet superbly effective.

So, why is it that it's not possible to be 'In the Zone' on every occasion when you really need it? Why is it that on another day, faced with similar issues, you are unable to cope the way you did when you were 'In the Zone'? There are many factors which can influence your performance: your colleagues and their performance, your own personal circumstances, age, role, health, what is happening at home or professionally, and, of course, fatigue. Fatigue is not just an issue that can impact performance during higher traffic/higher concentration levels. It also comes into play during the dreaded graveyard shifts, when traffic is low, boredom sets in, and your natural circadian rhythms start messing with your body and mind, and hence your performance.

It is clear from our own incidents database that fatigue is not a major contributing factor to incidents. It is cited under 'personal factors' as being contributory in less than 5% of our incidents. Hence, I don't see fatigue as being top of the hit list from a purely safety perspective based on previous incident data alone.

Hence, I have to conclude that, due to the natural limitations of incident investigations, fatigue may be more of a safety issue than we currently think it is.

I can recall one particular occasion when one of our controllers reported being fatigued after returning to work following maternity leave after the birth of her first child. She stated that her child was not sleeping well, which meant she was arriving at work feeling tired. Despite taking power naps in her breaks to mitigate the effects of her tiredness, she had a loss of separation which she is convinced was down to the fatigue she felt on that day. However, this is a very rare event, and investigation techniques, no matter how advanced, have to draw a line somewhere. For example, does an ANSP have the resources and expertise available to investigate the physiological effects of fatigue, or hormone changes, and draw concrete conclusions as to their contribution as a causal factor to an incident? I don't think so. Most ANSPs are limited to speculating that it may have contributed.

Likewise, when investigating incidents, if a controller reports that he/she was feeling tired at or around the time of the incident, can we then ask penetrating questions about their sleep patterns, circadian rhythms, eating patterns, what they were doing professionally or privately for the last 24/48 hours? If we did, would this enable us to then draw a meaningful conclusion that fatigue was definitely a causal factor? It is very difficult to conclude that fatigue is a direct causal factor in incidents given that there are so many other factors which contribute, and can be identified more easily.

Hence, I have to conclude that, due to the natural limitations of incident investigations, fatigue may be more of a safety issue than we currently think it is. This could be the case especially amongst the high-performance ANSPs where there is more pressure on controllers to handle higher traffic levels for longer periods of time, and who are therefore subject to the effects that higher concentration induces on the body and mind.

And this is where things get interesting from a safety perspective. Whilst most ANSP data suggests fatigue is not a safety issue of immediate concern, high pressure is being applied by our stakeholders (European Commission, states & airlines) and hence ANSP management, to increase performance and throughput whilst reducing costs.

This pressure has to be felt at the sharp end. There is a need for controllers and engineers to do more with less. To do this safely, fatigue should be appearing on the safety manager's radar screen. It may be time for the higher-performing ANSPs to put in place strategies designed to prevent fatigue, e.g. revisions of shift patterns, and personal strategies designed to enable controllers and engineers to

In the zone (cont'd)

understand and apply methods that will help them to personally prevent fatigue, or when they detect it, to be able to cope with it.

The benefits of such strategies would not only be realised through improvements to safety, but also through reduced sickness rates, improved staff morale, etc.

At MUAC, we have a controller working in our training section who has

Keith Cartmale

is the Safety Manager at Maastricht UAC.
Having led the development of the MUAC Safety Management System, He is keen to ensure that a human centred approach is taken to managing the safety issues that arise, and to further understand how to utilise human performance to improve safety. Keith is a Chartered Engineer who has worked in the ATM domain since leaving school, and has a masters degree in Safety Critical Systems engineering.

Ellen Beckers

works in the training section at Maastricht UAC where she has implemented the Competency Based Assessment Scheme. Ellen is an active Team & Resource Management facilitator, and a Critical Incident Stress Management peer. A controller for over 19 years, she is now utilising her experience and background to support students with mental coaching and stress management.

been personally affected by the effects of long-term fatigue. As a result, she has taken coaching, and has studied this area, in order to help herself and her colleagues understand this subject, and learn for the future. She now coordinates the delivery of internal training to staff on energy management, which is a voluntary course designed to teach staff how their bodies work, and how they need to work with their bodies in order to achieve optimum performance. It's about managing your energy in order to be more effective throughout the day and night.

These studies were based on the excellent work of Koen Gonnissen & Alain Goudsmet in their book – The Corporate Athlete (ISBN 9789013077162). Gonnissen & Goudsmet have drawn on their qualifications and experience as coaches to top athletes, and have assembled further training and coaching for employees and managers who are also faced with pressure to perform. Their book gives an "insight into the mechanisms to sustain high performance, and provides practical tips to help break through the daily grind of stress to achieve excellence without wasting energy". We have no doubt that these methods

are equally applicable to controllers, engineers, and managers working in the ATM community.

In addition to our voluntary energy management course, we are also rolling out a training module on fatigue/ stress management, which will be delivered during our 2011/2012 team & resource management campaign. This module is designed to make all controllers aware of fatigue and stress, and the simple steps they can take to prevent it.

1. Is looking after your health a priority for you?

2. How much time do you devote to looking after your health?

3. How do you recover after working?

4. Do you have conscious rituals for dealing with emotion, stress, sleeping, etc?

5. Are you aware of the effects of adrenaline, hormones, caffeine, etc. on your body?

6. Do you know how to utilise antidotes to compensate for the effects of adrenaline, hormones and caffeine?

7. Do you know how to balance sleep with private and professional calls on your energy, in order to ensure your batteries are well charged?

8. Do you understand the interaction between the mental, emotional and physical batteries that exist in all of us?

9. Do you understand what drains your batteries, and how you can recharge and strengthen them?

10. Do you understand the signals that indicate you may be under pressure?

To summarise, whilst fatigue is not a top-priority safety issue according to incident statistics, it should appear on safety managers' radars as an issue to be addressed in order to cope with the pressures that are anticipated as a result of the drive for increased ANSP performance. It may be timely to look at improving investigation techniques to help identify when fatigue is a factor, and what can be done about it. For those ANSPs whose performance is already high, they should be considering, or already have implemented, systematic programmes to help staff understand and deal with the effects of fatigue (both short and long-term fatigue), through learning from the professionals. If you start thinking of your staff as corporate athletes, and train them accordingly in these softer issues, you should find that they will be far more able to step into the zone when needed, and hence overall performance, health and morale will benefit.

Using caffeine strategically
to combat fatigue

By Dr Alexandra Holmes
As a fatigue management specialist, I spend much of my time training aviation professionals in how to manage fatigue...

Some training sessions assist managers in implementing organisation-wide fatigue management strategies, for example fatigue risk management systems (FRMS) or duty schedules that limit fatigue. I also provide air traffic controllers, pilots, cabin crew and mechanics with guidance on how they can personally manage the level of fatigue they experience. At these sessions there is always one topic that people are keen to learn more about – caffeine and how it can be used to strategically manage fatigue.

Caffeine is the world's most widely consumed stimulant and most of us consume some caffeine every day in the form of coffee, tea, chocolate or energy drinks. Caffeine's popularity is largely linked to the fact that, by activating our central nervous system, it temporarily overcomes tiredness and improves alertness and performance.

We like to consume caffeine in the morning to overcome sleep inertia, the temporary groggy feeling we have soon after waking up. Many of us also look for a cup of tea or coffee in the afternoon to get through the circadian slump in alertness that occurs at this time of the day. In industries such as aviation, that operate 24 hours and 7 days a week and require people to work in shifts, caffeine is widely used as a strategy to cope with work-related tiredness.

Although caffeine can be beneficial, it can also have significant negative consequences. Signs that you have had too much caffeine include anxiety, jitteriness, sleep disruption, heart palpitations and arrhythmias and stomach complaints.

Strategic caffeine use

In order to use caffeine strategically, we need to harness its benefits and at the same time limit its negative aspects. There are four steps you can take to achieve this aim:

1. **Combine caffeine with a nap**
   This sounds strange at first, but to enhance the benefits of caffeine the best advice is to combine your cup of coffee with a nap. Caffeine takes around 20 minutes to affect the nervous system and you can use this window to take a nap. Research shows that when you wake up, and the caffeine has taken effect, you will be more alert than if you just had the caffeine or the nap alone.

2. **Avoid caffeinated drinks with high levels of sugar**
   Be aware that soft drinks containing caffeine usually also contain large amounts of sugar - to counteract the bitter taste of caffeine. If you are using a caffeinated soft drink as a fatigue countermeasure, try to find a sugar-

Dr Alexandra Holmes

is a fatigue management specialist with over ten years' experience assisting aviation operators and other safety-critical organisations to develop and implement Fatigue Risk Management Systems (FRMS). An experienced researcher, technical author and trainer, Alexandra regularly undertakes fatigue risk assessments and large-scale research studies including the collection of data on sleep, fatigue and performance.

I hope that this new brew will pass me through this night shift...

free version. Sugar-free drinks will give you the benefits of the caffeine while avoiding the energy slump that can occur after we consume a large amount of sugar.

3. **Only consume caffeine when you need it**

As we rapidly develop a tolerance to caffeine, the more caffeine you consume during the day, the less of an effect it will have when you need it. If you limit your habitual caffeine consumption to only when you need it, for example to promote alertness during a nightshift, it will have a greater alerting effect.

4. **Recognise that people differ widely in their sensitivity to caffeine**

People who are sensitive to caffeine may find that one cup of coffee improves their alertness, while others need a couple of cups. If you are sensitive to caffeine you might not be able to consume caffeine after lunch if you want to have a good night's sleep, while other people can drink coffee before bed and still fall asleep without a problem.

How much caffeine do you consume?

To assist you to use caffeine strategically, you may find it useful to use the caffeine calculator to evaluate your daily consumption. Espresso, drop, filter and percolated coffee all have high caffeine levels, usually between 80-180mg, which is much greater than those of tea (approximately 45 mg) and instant coffee (approximately 75 mg). However, even if you only drink tea you might be surprised to see how much total caffeine you consume across the day.

Low daily caffeine intake of < 500mg is generally considered to be harmless. However, depending on when you take it, levels towards the upper end of this range may still affect your ability to get to sleep. If you are having difficulty sleeping you may want to try cutting down your caffeine consumption. Try stopping having caffeine after around 16:00 or towards the end of your shift and you may be surprised at how much easier it is to fall asleep later.

Consuming more than 500mg of caffeine per day is not recommended and people taking this much caffeine would benefit from taking steps to reduce their intake. Excessive caffeine consumption can be used as a crutch in an attempt to deal with high levels of underlying fatigue. If you consume a lot of caffeine you will first need to identify and address any reason(s) you may be feeling particularly tired. You may need to improve your sleep environment or speak to your doctor if you have been experiencing sleep difficulties.

Once you have successfully tackled the source(s) of your fatigue, you can begin to gradually reduce your caffeine intake over a period of time. It is important that you do not suddenly stop consuming caffeine as this can lead to extreme fatigue, headaches, irritability and anxiety.

How to reduce your caffeine intake without the headache

Reducing your caffeine consumption slowly, preferably over several weeks, will help your body adjust with fewer unpleasant side effects. Below are some tips on how to reduce your caffeine intake gradually.

- Mix decaffeinated coffee powder with ordinary coffee powder to make a lower-caffeine drink.
- Introduce one or two decaffeinated drinks into your daily diet. Then gradually increase this by alternating decaffeinated drinks with caffeine-containing drinks.
- Replace caffeinated soft drinks such as Coca Cola or Pepsi with caffeine-free versions or sparkling mineral water.
- Drink smaller volumes by using a cup instead of a mug.
- Try reducing the amount of coffee powder you use to make a lower-caffeine drink. When using tea bags, take the teabag out sooner.

Summary

In summary, caffeine is an effective short-term strategy for tiredness if used strategically. To harness the benefits of caffeine, while limiting the negative side-effects, try to limit your caffeine consumption to only when you need it to promote alertness. Too much caffeine can cause anxiety and disrupt your sleep, thereby actually making you more tired. For maximum benefit during a difficult shift, have some caffeine and take a short nap while you wait for the caffeine to take effect.

Finally, remember caffeine only masks or delays fatigue – the only real solution is sleep! ₷

A fatigue risk management system – the way forward?

By Lydia Hambour

Fatigue is a known contributor to aviation accidents. This has been acknowledged by the NTSB through its most-wanted transport safety improvements list, where action to reduce fatigue-related accidents in aviation remains a critical item requiring attention...

Lydia Hambour

Lydia is currently the FRMS Safety Manager at easyJet, part of the Operations Risk Department. Prior to this Lydia worked in safety and project related roles with Jetstar Airways and Adelaide Airport while completing a double bachelor's degree in Technology (Air Transportation Management) and Business (Management) at Swinburne University, Australia. Lydia is responsible for the development of FRMS Safety, including integrating the system operationally and assessing the impact of crew fatigue on performance through collaborations with NASA Ames and Imperial College London on the Human Factors Monitoring Programmes.

The acknowledgement that current fatigue management strategies are ineffective is a sentiment shared worldwide. Both ICAO and EASA have recently issued guidance recommending management strategies to address the fatigue risk threatening safe airline operations. So why may there be resistance to full implementation of a fatigue risk management system (FRMS)?

24-hour operations expose employees in the aviation industry to varying and often lengthy periods of time on duty, disruption to circadian patterns compounded by reduced and often interrupted rest periods. On top of this are workload influences, including external and internal factors that can vary from one duty or shift to the next. These hazards can interact and result in a fatigued employee – one whose ability to perform safety-related duties is impaired.

What is a FRMS?

A static means of fatigue management, such as prescriptive rules, cannot flex or adjust to the operating environment that exists at any one time and in any one place. For example, a legal twelve hours' time on task limitation is the same for an aircrew member operating a two-sector duty at the start of a shift sequence following multiple days off and experiencing minimal workload or hassle factors as it is for another aircrew member operating their last shift of a six-day sequence of duty, flying into a category C airfield and with an inexperienced co-pilot. This is clearly simplistic. Such examples can be found in all areas of aviation, be it airline operations, maintenance, air traffic control, etc.

On the other hand FRMS provides a way of extracting data from the specific operational environment and comparing it with scientific knowledge on sleep and shift sequences. It therefore effectively manages the risks posed by fatigue as a result of the operational circumstances that actually exist. It is proactive and continuous so as to identify the risks, implement mitigating strategies and review the outcome, ensuring the risks are controlled effectively and continuously.

How do I implement?

By its dynamic, adaptive and analytical nature, FRMS is not easy to implement. It is multi-faceted rather than binary. FRMS requires that an operation be flexible, with a willingness to change if and when required. This may be for all or only specific parts of the business as determined. For large organisations, which are highly automated and systems-dependent, this can be extremely difficult given their inherent inertia and legacy processes. Small changes may require lengthy lead-in times and complex systems integration. This will therefore necessitate careful planning by subject matter experts, including impact forecasting which must account for varying circumstances. Simply relying on the legal limitations as a means of controlling the fatigue risk is easy; however, it is also becoming recognised as incomplete and therefore unacceptable. FRMS requires education, increased expertise and understanding, but any investment made is recoverable through the accrued benefits it brings.

We've come up with a technical solution to support you during those long lonely night shifts...

Is it worth It?

In essence FRMS exists to ensure an organisation can proactively manage the operational fatigue risk, thereby reducing the chance of a serious accident linked to fatigue. Yet, simultaneously, as alertness increases, we can expect to see a reduction in the incidents, cognitive slips and lapses caused by fatigue. Human factors degradations such as impaired decision-making, reduced communication and increased risk taking will diminish. These safety improvements can have a quantifiable benefit to the organisation through a significant reduction in insurance premiums. As employee alertness improves, recovery is optimised, leading to a better work/life balance for the individual and reduced attrition for the organisation. Furthermore, absence due to fatigue-related sickness is reduced, bringing greater stability to the operation and heightened performance.

At what cost?

The safety benefits of FRMS are apparent but the improved efficiencies which are intrinsic to a well-developed FRMS can equally be quantified. Predictive fatigue models can be utilised to highlight the productivity restrictions in prescriptive flight time limitations and to suggest the FRMS-managed variations that can provide additional flexibility (within an appro-

priately risk-mitigated environment). However, predictive fatigue models are only one tool within an FRMS toolkit. By implementing an array of fatigue risk identification strategies such as field studies, surveys and employee reporting, the operating environment can be fatigue-risk assessed. Working with the local safety authority and all other stakeholders the risk areas, as identified, can be targeted using specific management strategies with similar beneficial outcomes for both safety oversight and productivity.

What will they say?

It is evident that the FRMS approach requires a new way of thinking that goes beyond the certainty of "compliance "or "non compliance" assessments of safety risk. It therefore requires a programme of education and awareness training so that all parties are clear about their obligations. If understanding of FRMS is unclear it may be perceived solely as a means of increasing employee productivity. Conversely, at the other extreme, it may be seen as facilitating employee absence through providing a readily accessible justification based on abuse of a safety absolute. To further alleviate this possibility, it is vital that an FRMS is based on scientific evidence, objectivity and transparency and is underpinned by organisational commitment to a just culture and non-jeopardy reporting.

Who needs convincing?

It will be apparent that to ensure the success of FRMS, buy-in from all parties is essential. It will facilitate the acquisition of data through clear communication channels that enable risks to be reported freely. Safety action groups can then review the data to decide on appropriate risk mitigating action. Ongoing assessment and review of fatigue controls by all stakeholder departments is essential for success. Trust in FRMS is key. A proven and externally supported method of work practice and validated results, together with feedback to employee groups will facilitate such acceptance on their part. Quality assurance and ongoing communication with the safety authority or regulator will give reassurance that FRMS can effectively perform internal governance. The requirement for intensive but static external audits will diminish as the regulator is updated on the proactive risk management capability on a regular and ongoing basis.

Ultimately, FRMS offers an enhanced method of managing fatigue risk in an organisation which can simultaneously deliver improvements in employee lifestyle and productivity. However it also requires a move away from the certainties of prescriptive rules to reflect the operational and individual circumstances that exist at the specific time and place. This in turn necessitates investment in education, systems and processes in order to overcome the inertia which is a part of more static legacy solutions. The evidence to date from those who have pioneered the FRMS philosophy is that such investment can deliver benefits to all stakeholders which are based on the foundation of enhanced safety performance.

But how do we measure it?

By Dr Arnab Majumdar

The evidence from various industries indicates that fatigue, primarily due to sleep deprivation, creates alertness deficits that in turn affect performance and thereby increase the chances of a serious accident. The solution therefore seems simple: eliminate fatigue by providing the necessary sleep and this should increase alertness and performance leading to the disappearance of fatigue-related accidents. End of….

Oh, if only life was that simple! Let us start at the beginning – what is meant by fatigue? In the "solid" world of materials engineering, definitions relating to the breakdown of a material due to repeated stresses form the basis of precise measurements. As soon as we get into the world of that most tricky of engineering materials, the "human being", then fuzzy definitions abound. Is fatigue something we intuitively feel or is it something that can be defined precisely, rather like the extent of progressive and localised damage to a material under a specified cyclic loading? Indeed, can it be both a subjective "feeling" and an objective "measure", and are these two related?

If definitions are unclear, how about measuring fatigue reliably? If it is about feelings, then surely all we need to do is ask individuals if they are tired and to what extent. The evidence though shows that humans are not necessarily good at judging when

they are fatigued. And as if that was not enough, in the complex modern world of aviation operations, organisations cannot hope to provide an appropriate level of service based simply upon their critical personnel's feelings. However, to ignore the subjective nature of fatigue leaves the organisation vulnerable – after all, you don't want someone who feels exhausted to be sitting at controls.

And if we are measuring something objective, what should that something be? The number of hours of sleep every night, or its quality, however that is defined? Or should we look at physiological measures related to the human body? Which will be the best indicator?

The evidence though shows that humans are not necessarily good at judging when they are fatigued.

Suppose though that we can measure fatigue reliably, and acknowledging that fatigue affects performance, how can we assess if it affects safety in particular? After all, granted that fatigue may reduce performance, but will it actually compromise safety to the extent of causing incidents and accidents? Or is there an acceptable level of performance decrement due to fatigue that organisations and the public can tolerate?

These were the research questions investigated by the Air Traffic Management (ATM) Research Group at

Imperial College London in conjunction with easyJet. As Lydia Hambour has highlighted in detail elsewhere in this edition, easyJet have implemented a fatigue risk management system (FRMS) which uses a variety of methods, including field studies, surveys and employee reporting in order to assess fatigue risk associated with the operating environment. This article elaborates on one aspect of the FRMS studies relating to a 3-week long trial to measure variety of fatigue, alertness and performance measures for a group of the airline's pilots.

Let us start though with a practical measurement problem. Much of the scientific literature on fatigue has involved experiments in controlled laboratory settings, as far removed from the "real world" of low-cost carrier (LCC) operations as is possible. Typically pilots can fly up to 6 sectors (i.e. routes) in a day's duty, and as an LCC, easyJet has 20-minute turnarounds between flights that are task-driven. Just in case there have also been delays during the day's flight schedule, the flight crew are under even more pressure during this turnaround. Therefore to conduct any tests to measure fatigue and its impacts must not interfere with any operational duties. On top of this, most of the flight sectors for the airline are relatively short (between 30 minutes to 4 hours), with little chance of administering tests during duties or solving any equipment glitches. Both hardware and human resource requirements thus need to be handled with care to ensure maximum cooperation from the flight crews. In these circumstances therefore, the need is to determine what tests can be feasibly conducted to provide meaningful, robust results without causing operational risks and increased costs.

An additional consideration involved setting the baseline for the subsequent measurements. Again, the controlled experiments literature provides few guidelines for the operational setting. Instead, the flight schedule for the 22 pilots taking part in the trial was designed so that they could be monitored for a 23-day period including three days off at the start and end of the monitoring period in order to establish baseline measures and to permit recovery from prior duty sequences operated. The pilots operated a specially designed schedule that involved three consecutive early start duties followed by two late finish duties (Block 1). This enabled data on performance and sleep to be collated for the first of the transition changes. Following Block 1, three days off were provided. The second duty block (Block 2) contained one further transition change and the duty sequence closely reflected the timings (Block 1). Two days off were provided following Block 2 before the pilots completed a further block (Block 3) to enable com-

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But how do we measure it? (cont'd)

parison in performance levels following two days off with that following three days off.

And so what to measure? Kilner and Cebola have noted in this edition that fatigue is assessed by a combination of subjective and objective measures. Various studies show that the schedule affects fatigue, hence the need to monitor the schedule design, e.g. duty time duration, the number of early and late duties and number of rest days. Furthermore, both the duration (cumulatively collected) and quality of sleep was measured, as was the subjective alertness of the pilots. To measure performance, the psychomotor vigilance task (PVT) was used. This is a simple task where the subject presses a button as soon as the light appears. The light will turn on randomly every few seconds for 5–10 minutes. Both the pilots' reaction time (RT), together with an assessment of how many times the button is not pressed when the light is on, provide a numerical measure of sleepiness by assessing lapses in the subject's sustained attention. To collect this plethora of measures, specially designed workbooks were completed by the pilots, which included their subjective fatigue, sleep and alertness ratings and in addition they wore actiwatches to record their sleep and conducted the PVT tests using hand-held personal digital assistants (PDA).

Prior to any analysis, the first task involved assessing whether the pilots were uniform as a group or whether they acted as individuals. By far, uniformity was observed, thereby allowing the results of statistical analyses on the 22 pilots to be robust and generalised. Now concentrate – here comes the science bit!

When fatigue, alertness and sleep were subjectively assessed, in the majority of cases the pilots felt moderately to extremely tired before going to sleep, and much less tired after sleeping, and they evaluated their quality of sleep to be good or average. Interestingly there was a very high degree of correlation between the pilots' self-assessed subjective sleep durations and objective sleep duration obtained from the actiwatches, showing that when it came to assessing sleep the pilots were good judges.

Based upon the baseline performance of the mean PVT value for the first duty day in Block 1, analysis indicated no obvious patterns between the average daily performance and the sleep duration or sleep efficiency. The relationship between subjective alertness measurements with the performance values per sector indicated that in general:

i)   better performances (i.e. PVT values) are more often associated with good alertness levels, whilst
ii) the worst performances are more associated with worst alertness levels.

The effect of duty transitions is important as it can be expected that there will be a level of performance decrement associated with duty transitions due to the sustained period of wakefulness and acclimatisation to early-duty sequences operated beforehand. Transitions were defined, in this study, as the changes between the early and late duty days, and rest and duty days.

The effect of transitions on daily average cognitive performance, average alertness level and objective sleep duration indicated that in general the performance on the first late duty day is no worse than that on the previous early duty day and also that performance on the first duty day is no worse than that of the previous rest day. And when it comes to alertness, there is no correlation between early – late days or indeed between rest and duty days. These results indicate no obvious performance decrements associated with duty transitions under the specified FRMS transition guidelines.

During the duty blocks, when it came to self-assessed alertness, the pilots rated themselves as moderately tired. They appear to fully recover after the first duty block to being a little tired. Following the second block and two rest days, the pilots indicated they did not fully recover to this level. This trend was supported by the group PVT variation per block, though the performance variation was slight. A review of cumulative sleep debt per operated block set against a benchmark figure of 8 hours again showed that crew are almost fully recovered after three rest days (disregarding off-duty social interests) and less recovered after two rest days. Based upon these results, easyJet adapted their schedule to ensure adequate rest and recovery for the pilots.

Fatigue in air traffic control

By Professor Philippe Cabon

Introduction

Fatigue is known to be a major risk for safety in aviation. Even if an accurate quantification of the contribution of fatigue in accidents is currently impossible because fatigue is not systematically investigated by a standardised procedure, it is classified as one of the "most wanted" factors by the National Transportation Safety Board (NTSB): "The Safety Board has long been concerned about the effects of fatigue on persons performing critical functions in all transportation industries including flight crews, aviation mechanics, and air traffic controllers". Since the ini-

tial statement from NTSB recommendations, it is clear that little progress has been made by the industry to address this critical safety issue despite the large amount of available scientific knowledge. The reason is probably because fatigue is a complex concept raising issues beyond safety such as productivity and social aspects. Therefore, fatigue cannot be simply prevented by the application of scientific knowledge but needs a case-by-case approach. This paper summarises the main available scientific knowledge on fatigue, and from this body of knowledge provides some practical recommendations.

Basic knowledge on fatigue

Although widely recognised as a hazard, there is surprisingly no consensus on what fatigue is exactly, even among

scientific experts. However, Williamson et al proposed to define fatigue as "a biological drive for a recuperative rest." In this perspective, fatigue covers a range of manifestations (physical and cognitive) that results from the absence of rest. One viewpoint could be that fatigue is like hunger and thirst, a signal that alerts us that we need to take a rest. This means that just as for hunger and thirst, it is a normal, physiological state that cannot be totally suppressed. We might just consider preventing it or mitigating its effect to avoid adverse safety outcomes.

Looking at rest, two main aspects should be considered: rest as defined as the end of a given task and rest as the production of sleep. The first type of rest is associated with specific and task-dependent fatigue (muscular, sensorial, mental, etc.). The second type of rest is linked to a more general fatigue manifestation, namely sleepiness. The present paper will focus on this last aspect of fatigue as it is particularly important for ATCOs.

Sleepiness is known to be mainly related to 3 processes (Figure 1):

- the process C for circadian, regulated by the so-called biological clock
- a homeostasic process, the process S associated with the amount of prior wake and amount of prior sleep
- a process W (waking) which reflects sleep inertia, i.e. "a transitional state of lowered arousal occurring immediately after awakening from sleep and producing a temporary decrement in subsequent performance" (Tassi and Muzet, 2000).

This model predicts that at least two conditions are needed for sleep to

Figure 1. The three-process model of alertness.
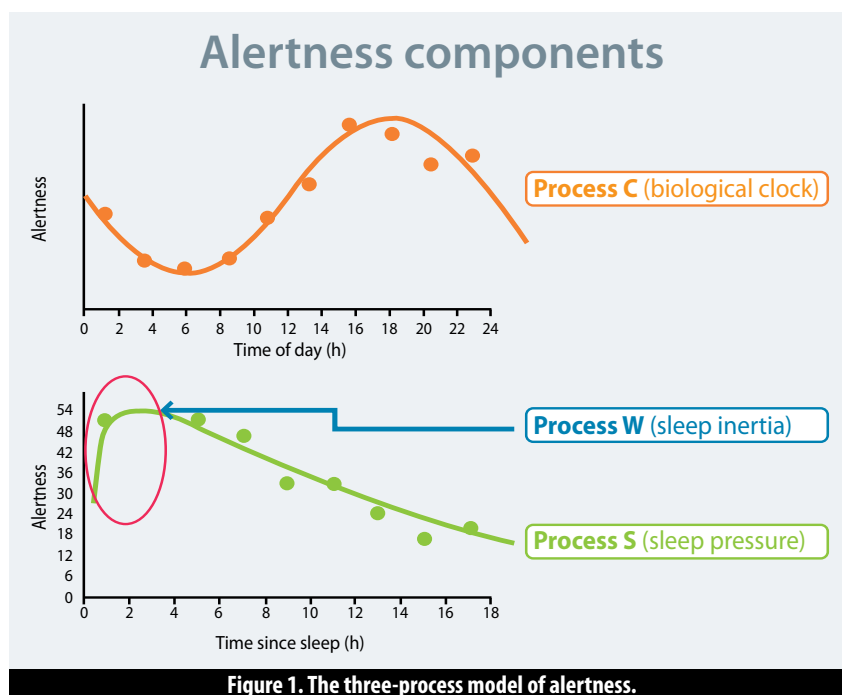
be triggered: a certain level of sleep pressure (homeostatic factor) and an appropriate timing (circadian factor). Under some circumstances, only one condition is met, e.g. during daytime sleep after a night duty, the sleep pressure is maximum but the timing is not appropriate, leading to a disturbed and shortened sleep.

Process W is also an important factor to be considered as it might have a safety impact when considering napping during duties (see next section). Two important features of our biological clock have to be kept in mind when considering the effects of hours of work on ATCOs.

> From an organisational point of view, two levels should be considered in air traffic scheduling: the organisation of the duty cycles ... and the organisation of breaks within the duties.

The first of these is that we have a natural trend to delay our sleep-wake cycle. This is particularly clear during days off or holidays, with a spontaneous tendency to delay our sleeping time. This natural trend is essentially due to the fact that the internal period of our biological clock is not 24 hrs but rather 25 hrs. This was discovered in the famous experiment on temporal isolation where subjects were kept for weeks in a cave totally isolated from external time cues (Figure 2). After a few days, the period of the biological clock increases (indicated by the body temperature and sleep-wake cycle). This natural trend explains why it is so difficult to go to bed early the evening

before a morning shift. It also shows the importance in our daily life of exposure to time cues, especially bright light!

The second important feature of our biological clock is its inertia to change. Therefore, any shift in the work-rest cycle (e.g. shift work) does not induce an immediate adaptation of our biological clock. That is why after days off, when it's time to return to work we have difficulties to advance our sleep-wake cycle leading to fatigue and a decreased performance.

Therefore, the primary effect of irregular hours of work is sleep deprivation. Sleep deprivation is known to produce several detrimental effects on cognitive functions and interpersonal communication. It has been demonstrated in laboratory research that moderate sleep deprivation produces

impairments in cognitive and motor performance equivalent to legally prescribed levels of alcohol intoxication. Even though alcohol and sleep deprivation produce different behavioural effects, this experiment strongly suggests that sleep deprivation can seriously affect safety. Two aspects should be distinguished when addressing sleep deprivation: acute and chronic sleep deprivation. Several researchers suggest that chronic sleep deprivation has the same effects as acute sleep deprivation. This means that slight sleep deprivation cumulated over several days produces an effect equivalent to that of acute sleep deprivation over one period (Figure 3). This result is critical when considering shift work where slight reductions in sleep are repeated duty after duty. This raises the importance of a shift pattern that allows sufficient time off to prevent the accumulation of sleep loss.
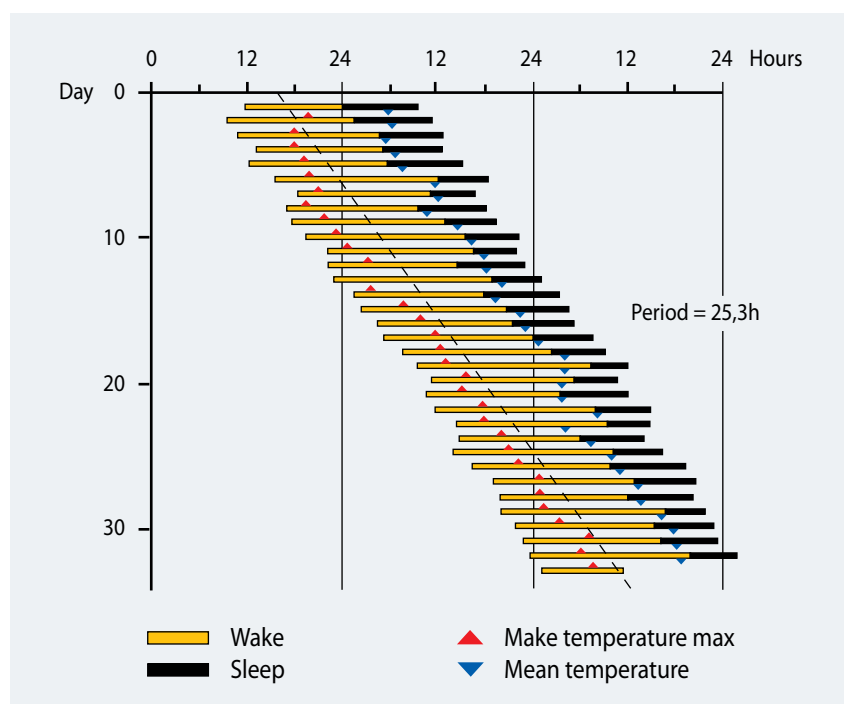

Figure 2.
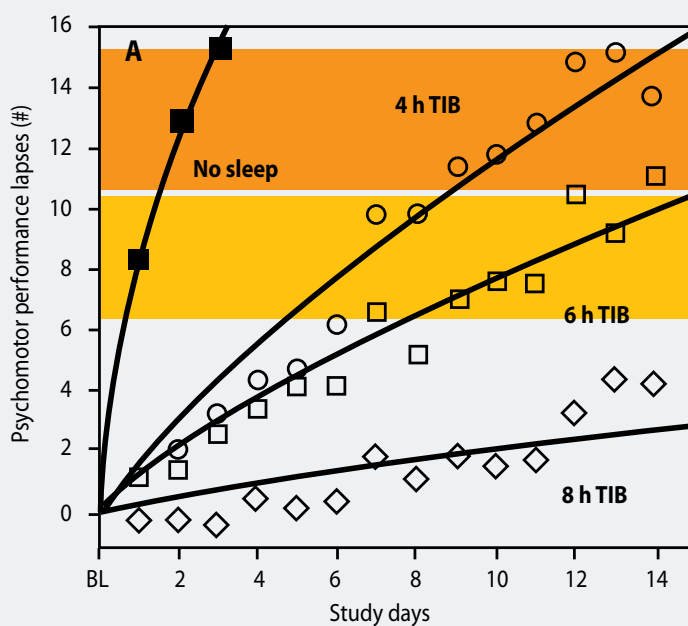**Free running of biological rhythms during temporal isolation experiment (Wever, 1979)**

Figure 3.
Chronic sleep deprivation produces the same effects as acute sleep deprivation

Figure 4. A model of fatigue and safety

It is clear that sleep deprivation has a significant effect on a wide range of cognitive and motor performance. However, does this mean that sleep deprivation has a demonstrated effect on safety?

It seems that the answer to this question is more complex than one would intuitively think. In fact, several findings suggest that the link between sleep deprivation and safety is complex and influenced by many factors. One of the key factors that could explain this complex link is fatigue awareness. On the one hand, being aware of fatigue would lead to the development of strategies to either reduce fatigue or to protect performance (Figure 4). On the other hand, being unaware would not lead to the development of these strategies, which in turn would impact performance and consequently safety. This level of awareness would be probably low at intermediate levels of fatigue, leading to an increased risk for safety. Therefore, it shows the importance of fatigue training to improve awareness and the development of personal and collective strategies.

Fatigue countermeasures for ATCOs

When applied to ATC, the body of scientific knowledge has practical implications both from an organisational point of view and for the development of personal strategies intended to cope with fatigue.

From an organisational point of view, two levels should be considered in air traffic scheduling: the organisation of the duty cycles (i.e. the sequences of duties) and the organisation of breaks within the duties.
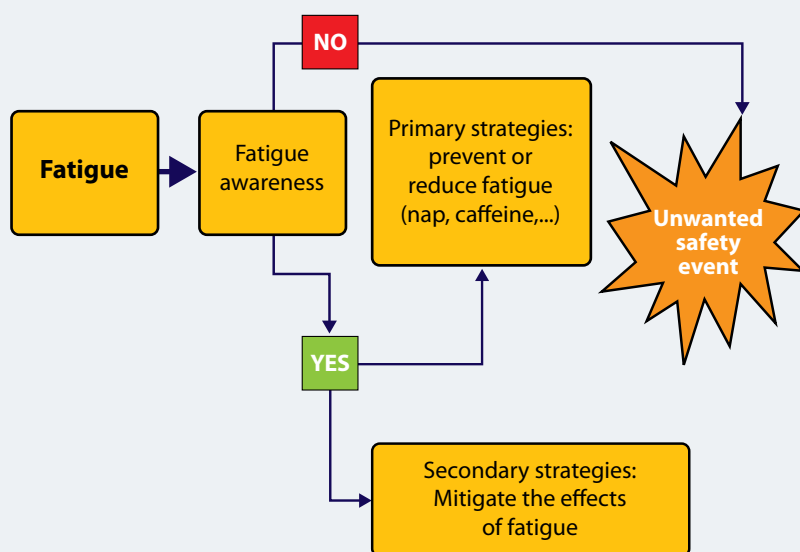
Fatigue in air traffic control (cont'd)

Organisation of duty cycles is a difficult issue as there is no ideal scheduling. Scheduling is always a compromise between safety, health requirements, productivity and social acceptance. One of the first aspects to consider is the direction of shift, i.e. clockwise (delayed rotation) or counterclockwise (advanced rotation). From a physiological point of view, most shift work experts argue that clockwise rotations are better than counterclockwise rotations because of the dynamics of the circadian cycle, which has a natural delaying trend (Figure 5). However, from the ATCO's perspective these delaying schedules are often unpopular as they tend to compress the weekend. Therefore, if a clockwise schedule is adopted it is necessary to find a way to keep sufficient time off for the weekend period. Another critical aspect is the scheduled time off between shifts, which should not be less than 10 to 13 hours to avoid sleep loss. Of course, the best compromise will
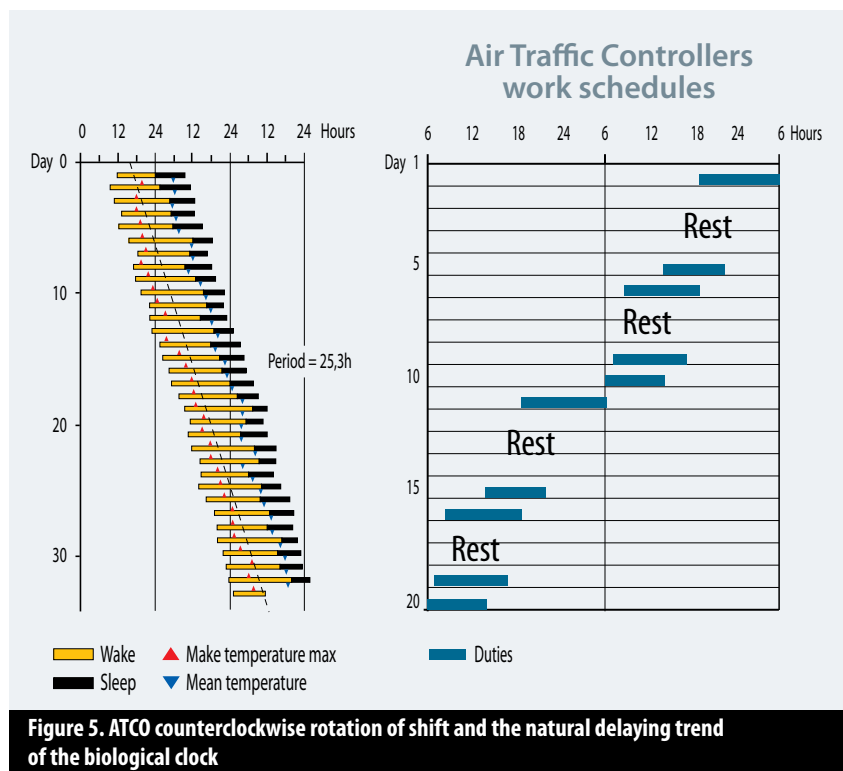
Figure 5. ATCO counterclockwise rotation of shift and the natural delaying trend of the biological clock
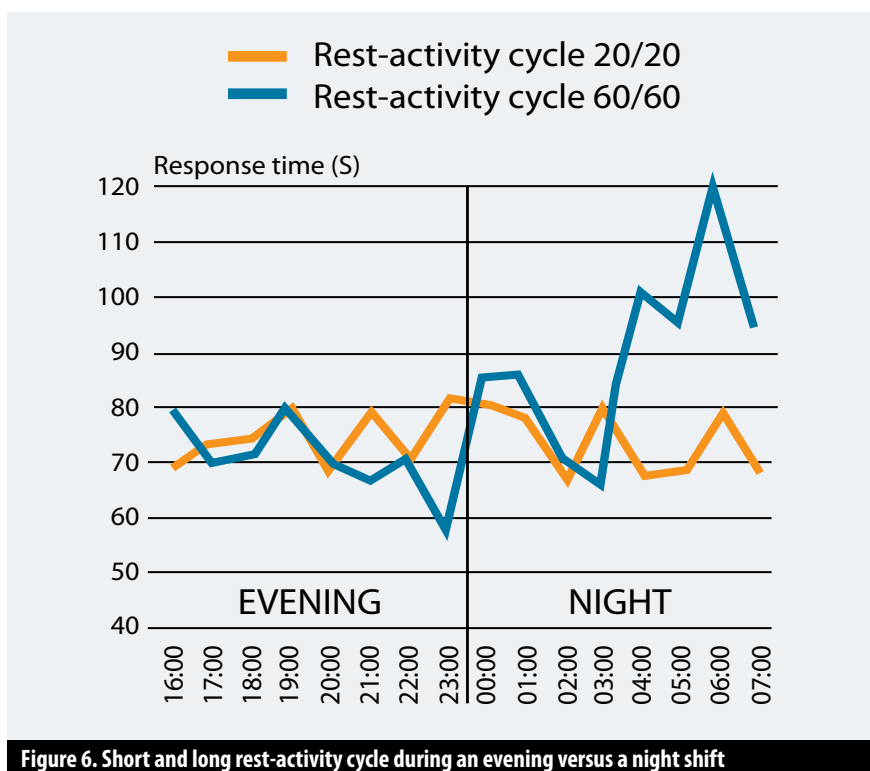
Figure 6. Short and long rest-activity cycle during an evening versus a night shift

When napping is scheduled close to the circadian low or in the case of a previous sleep deprivation, it is preferable to limit the duration of naps to 20 min to avoid sleep inertia.

be reached if ATCOs are consulted in the scheduling change, as it will increase social acceptance. Furthermore, scheduling design can now be supported and improved by the use of a predictive model of fatigue.
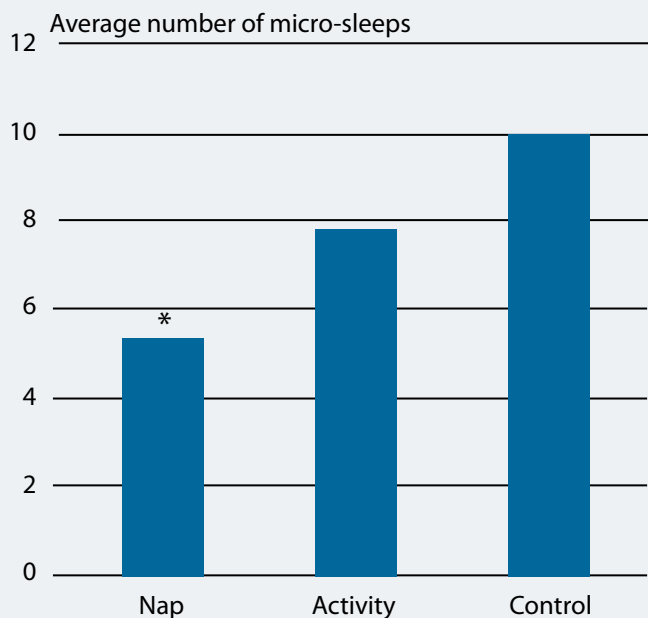
Figure 7. Reduction in the average number of microsleeps by ATCOs during the nightshift after a 20-min nap.
* Statistically significant difference between the nap group and activity and control group

Organisation of breaks during shifts is also a critical aspect because of the continuous level of attention that is required in ATC tasks. In a simulated ATC experiment, Pigeau et al (1995) demonstrated that the frequency of breaks should be adapted to the hours of work. Figure 6 shows that a quick work-rest cycle (20 min on/20 min off) produces the same performance (measured as the reaction time to detect aircraft) as a long cycle (60 min on/60 min off) during an evening shift. A reversed tendency was observed, during the night shift, when a significant increase in reaction time was seen for the 60/60 cycle in the circadian low (between 03:00 and 06:00).

One of the important issues concerning breaks is whether these breaks should contain sleep. Napping is probably one of the most popular countermeasures adopted by many employees in night and shift work. Although various research has demonstrated the beneficial effects of napping on alertness and performance, including in ATC (Figure 7), it is also a controversial issue because of the potential "side effects". These are linked to sleep inertia, i.e. the state of reduced alertness and performance that follows sleep. The duration of sleep inertia is usually measured as the time taken for performance to recover to pre-nap levels. This period can last from a few minutes to several hours depending on various factors, in particular in which sleep stage the waking up occurred (Tassi and Muzet, 2000). Sleep inertia is known to impact a wide variety of cognitive functions, especially an impairment of performance and reaction times and a reduction in memory ability.

Sleep inertia is greater the higher the quantity of deep sleep during the nap.

Therefore, napping during shifts should be implemented carefully by taking into account the timing of naps. When napping is scheduled close to the circadian low or in the case of a previous sleep deprivation, it is preferable to limit the duration of naps to 20 min to avoid sleep inertia.

Conclusions

Fatigue is a physiological drive for a recuperative rest resulting from internal processes that cannot be naturally suppressed. ATCO working hours led to various cognitive performance degradations associated with sleep deprivation and working at times for which humans are not biologically programmed. However, when considering safety, the impacts of fatigue are less clear as they are influenced by our own awareness of our state and by our ability to develop strategies to overcome the detrimental effects of fatigue. Therefore, the prevention of the negative safety outcomes linked to fatigue should make it possible to reduce the occurrence of fatigue with appropriate scheduling, but also by providing ATCOs with the means to detect and mitigate its effect.

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He is a member of the ICAO task force on Fatigue Risk Management Systems.

Did you say fatigue regulation?

By Stéphane Deharvengt

Fatigue regulation may appear to be a long and discouraging topic compared to lively accounts of operational situations where fatigue played a role. However, if you stay awake till the end, you might have learnt a few issues that really have an impact on how our industry has reached ultra-high levels of safety, by actually allowing pilots and controllers to manage demanding operational situations.

A case study, pilots' flight time and duty time limitations

A comparison of risky human activities shows that you cannot improve your level of safety if a certain number of evolutions are not accepted. One of those is the development of international regulation, compared to local rulemaking practices (Amalberti, 2003). This was the case when Europe embarked on developing harmonised regulation for airlines' operations with the adoption of JAR-OPS 1 in 1996. Interestingly, one section was missing, sub-part N for flight time and duty time limitations, the section which was supposed to cover fatigue issues. A few years after unsuccessful negotiations, the European Commission took charge with a view to reaching an agreement. Then it was the turn of the European Parliament to embrace this challenging task. To cut a long story short, it was not until the end of 2006 that a European regulation, the EU-OPS, was published with an applicability date of mid-2008. This regulation included the first Europe-wide requirements for flight time and duty time limitations. But the story does not end here, because in the meantime, EASA has been granted competencies in this domain and has had to publish its own regulation to replace EU-OPS. At the time of writing, the response of EASA to the comments received after the publication of the draft Implementing Rule for OPS has just been published (NPA 2010-14A, a 244-page document) and the final rule with its applicability date is still pending. Broadly speaking, it took us about 15 years to develop a regulation addressing rostering practices for aircrews.
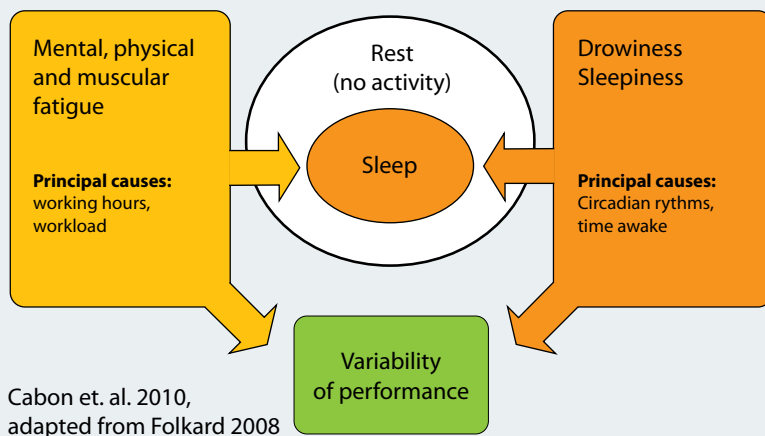
Analysing the complexity of regulating fatigue

Over the years, aviation has been the place for technological and operational developments (e.g. aircraft range capacities, opening of new routes), but also changes in the economic and social context (e.g. new airline business models, shortage of pilots), and evolutions in safety management (e.g. training, occurrence reporting, oversight). Those factors have contributed to the establishment of differences in the accepted consensus between states and/or between airlines. In a fierce competitive environment, operational flexibility is traded for flexible usage of the pilot workforce in exchange for various compensations in a win-win situation, supported by enhanced on-board systems.

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Mental, physical and muscular fatigue

Principal causes: working hours, workload

Rest (no activity)

Sleep

Drowiness Sleepiness

Principal causes: Circadian rythms, time awake

Variability of performance

Cabon et. al. 2010, adapted from Folkard 2008

Nothing but normal socio-technical process at work!

On the other hand, managing fatigue in regulatory terms was understood as prescribing limits on maximum daily, monthly, and yearly working hours, and requiring minimum breaks within and between active operational periods. This was in line with the understanding that long unbroken periods of work could produce fatigue (what is called 'time-on-task' fatigue), and that sufficient time was needed to recover from work demands and to attend to non-work aspects of life. However, improved scientific knowledge evidenced additional causes of fatigue, such as the importance of adequate sleep (not just rest) and the daily cycle of the circadian rhythms. The scientific view of fatigue and how it is addressed in regulations is increasingly out of sync. In parallel, our knowledge of how accidents happen has improved, first with the introduction of human performance aspects, but more so with the notion of in-depth systemic defences, the famous Reason's Swiss Cheese model. Prescriptive regulations defining limits for the organisation of duty and rest periods are not only an inadequate simplification of operational life – if you're inside the limits you're safe, if you're outside you're unsafe – but constitute only a single line of defence in the overall strategy for maintaining safety.

To further complicate the issue, although laboratory experiments have shown decreased performance for fatigued individuals, investigations of fatigue effects on real situations, especially on aircrew work, suggest a complex and non-linear link between fatigue and safety: teams in a highly automated environment might be able to develop strategies to mitigate the impact of fatigue. Fatigue awareness is probably an important factor that might explain this complex link between fatigue and safety (Cabon, at al 2008): if you feel fatigued, you may be more prone to err on the side of caution, whereas if you feel alert, you might feel overconfident. This is the wake-up call for an improved organisational safety strategy.

This analysis conveys the difficulty in accounting for complex fatigue management strategies by operational people in a regulation that acts as one constraint among many in the socio-technical environment of airlines. No wonder then that any evolution is bound to awake interesting parties with a start, as evidenced by recent discussions about the proposed EASA regulation.

Evolution towards fatigue risk management egulation

In the wake of safety management systems (SMS) implementation, several airlines have implemented the concept of fatigue risk management systems (FRMS) in the context of ultra long-range flights or short-haul flights in Europe. This flexible approach to managing fatigue requires the identification of fatigue-related risks (e.g. use of predictive models for guiding scheduling, accounting for extended duty periods or reduced rests), the implementation of mitigation measures (e.g. adequate accommodation, individual lifestyle) and the monitoring of potential effects on operations (e.g. use of aircraft recorded data, reporting, normal operations monitoring). The system is based on a prag-

matic review of operational practices augmented by scientific knowledge and tools. The FRMS regulatory approach can be seen as a concrete way for an organisation to adjust its practices by re-introducing safety as managed by humans in addition to safety as required by regulations: this is the organisational strategy for managing safety. The implementation process will obviously take time both for the operators and the regulators because of the complexity of the issue.

Are the lessons learnt applicable to ATM or other domains of aviation?

The differences for ATM are obvious: the regulatory system (there are no prescriptive safety figures for our rostering systems), the technological environment (automation and its constraints on proceduralisation are not there yet), team organisation (we're normally used to working with the same colleagues in a team), and so on. However, our understanding of the mechanisms related to fatigue impact on performance tells us that sleep and performance are mutually influenced by workload and working hours on the one hand and circadian rhythms and time spent awake on the other.

As humans adapt to the requirements of the tasks while managing their own resources, a regulatory process that accounts for such strategies is needed if we are to avoid unending disputes over how long a roster should be: science will be more useful in helping us design a strategy than for bickering about numbers. This far from easy or simple, but it is in line with the principles of SMS and the underlying concept of risk management: safety policy and allocation of responsibilities, risk management by the identification of vulnerabilities and implementation of mitigation strategies, assurance of safety by monitoring operational effects, promotion of continuous safety improvement.

The complementary nature of the various safety strategies in our industry (either at the level of the individual, the team, the middle management, or the organisation) is ultimately what makes it resilient. Food for thought, in case you have sleepless nights. 🗲

Fatigue and alertness management for ATC:
does it really have to pay off?

By Jean-Jacques Speyer

Reflecting way back to the early nineties, as we at Airbus were developing and validating fatigue and alertness management strategies with the Université René Descartes and under contract to the French DGAC, we performed numerous commercial long-range flights that eventually led to a getting-to-grips guide (in this case with fatigue and alertness management[1]) available to Airbus airline customers.

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During one of these flights, on a late night let down at the end of a trans-atlantic journey, we were vectored away for traffic spacing and after many long minutes on an outbound leg, the commander took the initiative to get back to the approach frequency to request further instructions. The answer came back just as soon: "Air BC, turn immediately to heading xyz for an approach to runway nm, sorry sir!" This non-standard end of a phrase left the crew some-what startled and surprised. Whilst hurriedly reprogramming their FMS, the captain said jokingly: "Guys, we haven't got a minute to lose!" And he added for us: "ATC should perhaps think of doing some of your fatigue and alertness management stuff as well!" Rightly or wrongly, they firmly believed that approach control had forgotten us because the frequency controller had somehow hit the sack himself… Or perhaps he had just come back from relief…

Unknowingly, this crew had triggered the saga of what was about to start on a much wider scale: the systematic transfer of sleep research to air traffic control to explore and solve pressing fatigue issues for air transportation actors. Granted that endeavours like this had already been made, but not to the point that they would eventually become fertile ground for sleep scientists to cooperate on a global scale. **Now that ICAO provisions require fa-**

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tigue risk management systems **for flight operations to take over a potentially wider role from fatigue and alertness management strategies, we are entitled to wonder whether all this could also become applicable to ATC.** Close examination of dedicated ATC studies reveals both differences and similarities with pilots. Having been actively involved in the domain as far as airline pilots are concerned, sheer curiosity made me reread bits and pieces of the literature, and make contact with former HF researchers now fully versed in the theme with ATC. Work and studies have been carried out by various institutions, from Massey University in New Zealand to the FAA's Civil Aero Medical Institute in Oklahoma, USA, and including the Université René Descartes in France, Murdoch University in Australia and the Volpe Center in Cambridge, USA. I also read articles on ATM shift-work management, readily available from SKYbrary. And in the process, I tapped into quite an exhaustive literature review of managing shift-work in European ATM performed by EUROCONTROL.

Even though ATC controllers do not go through time zones and suffer jet-lag, they work against their own body clock with shift systems, especially since night work is involved. These shift-work arrangements are hence associated with general syndromes such as fatigue and stress, sleep disturbance and debt, circadian rhythm disruption, gastro-intestinal disorders, impaired performance and family/social disruption. In addition, ATC workload varies considerably during the day, during the week and during the year. It is well known that many variations do exist in actual practices in ATC shift scheduling.

There are many different shift systems that have become widespread in the last few years. Alternate shift systems (moving every week) are more common in Europe than permanent systems. Forward rotating systems (CW) i.e. morning, then evening and ultimately night duty) appear to be commonly preferred to backward rotating ones (CCW), largely because of the belief that since humans by and large tend towards a 25-hour circadian clock, they will favour progressively

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advancing cycles. Forward rotating shifts appear to be more tolerable by the body than backward rotations (causing fatigue and sleep problems), often enabling more coherent free time. Worldwide research at some point had to document, review, evaluate and challenge all of this.

Fatigue and alertness management for ATC:
does it really have to pay off? (cont'd)

In 2006 EUROCONTROL performed a study aimed at identifying best practices to help define solutions for managing shift work in European air traffic management (ATM). This work [2,3] presented ways and means for facilitating the planning and management of flexible working practices to improve safety and productivity. The study underlined a higher risk of physical and mental impairment for those controllers working in atypical shift systems compared with employees with regular working hours. In particular this risk needs to be managed in the knowledge that:

- the risk increases from early to late shift and is highest during the night shift, short-term memory tasks being at their peak in the morning, and decreasing through the day,
- during dayshifts a break is due at the latest after 4 hours,
- tasks demanding high vigilance levels should be followed by a break after just 2 hours,
- the minimum duration of a break should be 10 minutes plus 5 minutes per hour of work,
- breaks should allow napping (typically 20 to 40 minutes) with ample time (15 minutes) to overcome subsequent inertia (period of grogginess experienced upon waking),
- the "hand-over after a break" was considered critical, as the potential for operational errors is highest and increases exponentially as we progress from dayshift to nightshift because the ongoing traffic picture has to be assimilated quickly,
- demands for designing night shift rosters should support European Directive 93/104, restricting shifts to 8 hours.

This research[2,3] concluded that an optimum shift system in ATM cannot be defined in absolute terms. The specific conditions of the work situation, the workload, its spatial and temporal distribution, individual conditions such as age, attitude, and social support and the organisational framework all play a vital role in the design of shift systems. The study provided 10 guidelines for shift-work design but acknowledges that some of these recommendations may be contradictory and cannot all be implemented at the same time. Particular choices have to be made: do we look for optimum regeneration after a shift or for the possibility of spending a maximum amount of time with friends and family? Even though it is very difficult to put the recommendations in a particular order, specific aspects take priority concerning the reduction of health risks. European guidelines concerning working hours hence take precedence, and require internal coordination.

In the US, Congress had mandated a study[4] in 1999 to conduct an extensive survey of sleep/wake cycles and performance of ATC operators. This included comparing rapidly rotating clockwise and counter-clockwise shift schedules. A third of the respondents said that variable shift work was more fatiguing, with progressively poorer sleep quality as they were getting through the working week. Younger subjects also experienced more car driving issues following shifts. But the study did not support the common belief that a clockwise rotation would result in significantly better performance for complex tasks. The FAA's Civil Aero Medical Institute[4] said that test performance was notably poorer during the mid-shift (night) and on the

do we look for optimum regeneration after a shift or for the possibility of spending a maximum amount of time with friends and family?

final (fifth) day of 2-2-1 (2 afternoons, 2 early mornings, 1 midnight) shifts. An ATC shift-work and fatigue evaluation followed with computer-based performance tests, actimetry (i.e. the use of wrist movement measurement devices to accurately ascertain sleep/wake occurrences) and logbooks. Sleep duration and quality, mood and sleepiness appeared to be a function of shift start time, with the preference going to the less abrupt rotations offering more recovery time. Quick-turn rotations, which allowed more sleep with at least 12 hours off (or more), also resulted in better performance and more favourable subjective reports. A subsequent lab study[4] confirmed few differences between rotating conditions. Performance was maintained during afternoon shifts, notably reduced during early morning shifts and dramatically reduced during midnight shifts irrespective of the rotating condition. The effects of a counter-clockwise 2-2-1 rotation schedule were no different to those of the clockwise variant. Early mornings and midnights remained a concern for maintaining performance in either rapidly rotating shift schedule. Napping was highly recommended, especially before the midnight shift, resulting in better performance and significantly fewer micro-sleeps. Besides offering a productivity boost, napping is also known to especially increase creativity and problem-solving skills.

In an early study[5] comparing clockwise and counter-clockwise rotations, Barton and Folkard concluded that "the critical feature may not be related entirely to the direction of rotation but to a combination of direction and the length of break when changing from one shift to another". And more recent work by the Université René Descartes[6] on behalf of the French CENA (Centre d'Etudes de la Navigation Aérienne) used both subjective (sleep log, shift difficulty, fatigue and sleepiness scales) and objective data (actimetry and electro-encephalogram (EEG) recordings) to demonstrate that ATC controllers' on-the-job fatigue and sleepiness may not result just from work schedules, but rather from complex interactions between schedules, workload, and stress during the activity. Measurements were correlated with daily assessments of sleep latency (the time it takes to fall asleep) and of sleep quantity (and awakenings) as well as sleep quality during rapidly rotating (i.e. short breaks) backward shifts (CCW) over 10 days for 23 volunteers, 8 of whom had EEGs. This again revealed how fatigue and sleepiness can be at odds.

NASA's Aviation Safety Reporting System[4] was screened for major operational errors, such as a reduction in applicable separation minima. This
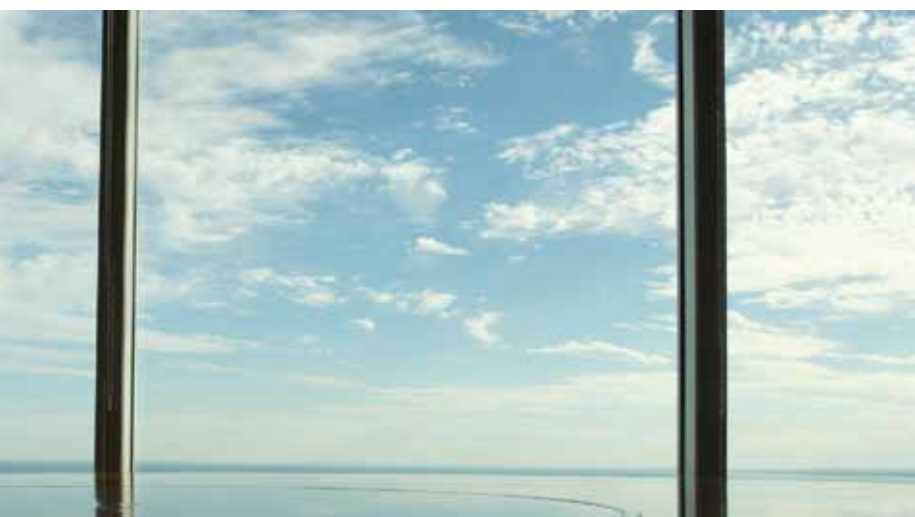
Fatigue and alertness management for ATC:
does it really have to pay off? (cont'd)

confirmed that a high percentage of errors do occur during midnight shifts. Also, nearly half of all the errors recorded in daytime occurred within 30 minutes in position, usually upon returning from a break. Schedule variability pointed to the need for greater care in the actual planning of controllers' working hours and to the actual timing of their sleep windows, which by the way is also a matter of personal discipline. Some incidents indeed point directly to systemic dysfunctions related to fatigue and which could be remedied. Some highlight the impact fatigue has on controller performance.

" At 09h07 Central Standard Time, a controller issued conflicting clearances to two aircraft, resulting in a runway incursion at XYZ airport. The controller cleared an aircraft A to cross runway xy and, less than 15 seconds later, cleared an aircraft B to take off on the same runway. The pilots in the departing aircraft B observed aircraft A moving toward the runway, rejected the takeoff, and stopped before reaching the taxiway intersection where aircraft A was to cross. The controller later stated that when he issued the takeoff clearance for aircraft B he had forgotten having instructed aircraft A to cross runway xy. He stated that he was sequencing incoming flight progress strips when he forgot about the crossing clearance and that he had neglected to use a memory aid to remind himself about the crossing traffic, as required by facility operating procedures. The investigation determined that the controller had worked an 8-hour shift the previous day until 2130 and was then off duty for 9 hours. Because of commuting and personal activities, he slept only about 4 hours before returning to work for the incident shift,

which began at 0630. He reported that he felt "semi-rested" during his shift but was "not as sharp as he could have been." He stated that the second shift had been a quick turnaround with no coffee. "

Having contributed to the world's very first fatigue risk management system[1,8] with the advent of the ultra-long range A340-500 at Singapore Airlines, I realised that pilots are certainly not unique, and that there is definitely room for dedicated FRMS[8] in ATC (and maintenance) as well.

This is where FRMS[8] must finally come into its own, providing the educational package on fatigue, sleep and alertness, proposing ways and means of evaluating performance risks and preventing undue handling. Practical FRMS[8] that have to include organisational fatigue policy, alertness models, risk management frameworks, communication strategies including training and education. But that also offer necessary tools to create alternative

schedules and shifts. And that can make necessary checks & balances to help administer resources accountable for fatigue and alertness management. Wouldn't we be asking too much if on top of all this, FRMS[9] had to offer compelling business cases with adequate cost-benefit leverages so that the end justifies the means? Does it really have to pay off in that way? Do we have to literally transpose innovative FRMS[9] (such as the one devised at easyJet to enable work outside current flight and duty time limitations) to the somehow different world of ATC?

It is somehow symptomatic of the increasing complexity of our society to witness so many basics of our trade

My message is that in addition to dry theory... well-written stories, and in general story telling, can guide us in our behaviour.

having to be formally documented, so many of our working practices having to become structured processes because so many of our natural risk mitigating practices have in fact become slightly atrophied.

Perhaps the best remedy of all remains the "classical call for duty" and proper "airmanship", transposed to controllers.

Disregarding the contrasting results from these study reviews, the best news about all this in the end is seeing so many researchers all over the world now able to talk to each other with more scientific evidence based on actual ATC fatigue research, each in their own setting. And hence create conditions, inventive schemes and solutions to induce documented change for the sake of safety.

And perhaps good narratives, real-life stories written as self-study notes, are just as desirable as well. These would be real-life examples, such as those developed for pilots in the Operator's Guide to Human Factors in Aviation (www.skybrary.aero/index.php/Portal:OGHFA), to convey the stories as seen through the eyes of the participants. **My message is that in addition to dry theory (which is also very dependent on the socio-economic (EU vs US) context), well-written stories, and in general story telling, can guide us in our behaviour.**

"My mind clicks on and off… I try letting one eyelid close at a time while I prop the other open with my will. My whole body argues dully that nothing, nothing life can attain, is quite so desirable as sleep. My mind is losing resolution and control." C.A. Lindbergh, The Spirit of St. Louis.

Well-chosen examples that are safety-effective can make a good point. These would be a necessary complement to FRMS … once they have been broadly proven and implemented[9].

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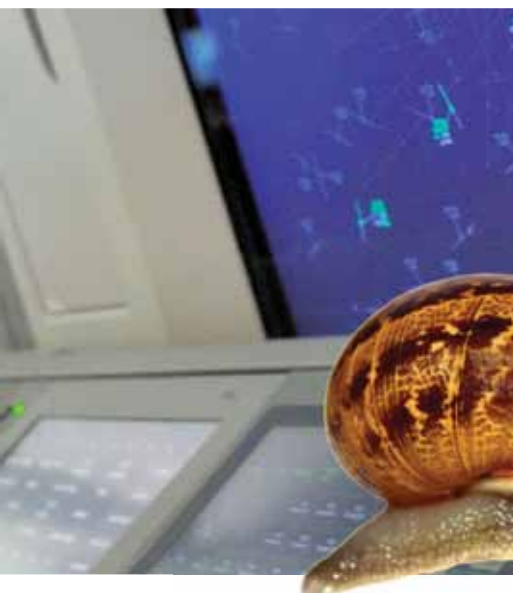
Breaks from operational duty

Best practice guidelines from human factors research for optimising human performance and reducing fatigue-related risks. By Steve Shorrock

Breaks from operational duty are an important factor in the management of fatigue. But as highly committed and professional operational staff often perform several secondary tasks and activities – inside or outside the ops room – breaks can become a victim. Breaks seem to be used for a wide variety of activities. A controller once said to me that working through breaks was often necessary for him to complete his secondary role…in safety management. This tendency to use breaks to perform tasks that add to fatigue, rather than reduce it, can increase over time without being noticed. In the end it may seem like the normal way of working. It is too easy to forget the important role of breaks in managing fatigue – visual, mental and physical – and of course in managing stress.

Steve Shorrock

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He has led human factors and safety assurance for a number of high-profile multi-million dollar transport infrastructure projects and has helped develop human factors techniques that are in use internationally.
He is currently a Safety Development Project Leader at EUROCONTROL and an Adjunct Senior Lecturer at the School of Aviation, University of New South Wales.

Fatigue is a core issue in human factors. So what activities are acceptable from this point of view? Anyone with some exposure to the field of human factors will not be surprised to hear that there is no black and white answer. But some general guidelines can be offered from the research on fatigue and vigilance.

Let's start by asking, what is the purpose of a break from operational duty from a human performance viewpoint? Operational tasks are often visually demanding, involving monitoring the outside view, the situation display, or other screen-based work. This work contributes to visual fatigue, even when you are not particularly physically fatigued. Operational work can also involve intense periods of typing, writing or other inputs. You may notice how this brings about feelings of tension in the hands, arms and shoulders. Similarly, the work can often involve static postures, and so more general physical fatigue or discomfort can result. In high workload periods, mental fatigue can build up. But low workload periods can seem even more mentally tiring, and it is during these times when vigilance can really suffer.

So breaks are needed to recover from a variety of demands and the needs from a break will vary. Depending on the operational activity, you may need to **rest**, or **relax**, or **re-energise** during the break. We could put break activities into three categories, and as there are no black and white answers, we'll call these red , amber and green activities.

Red activities

There are some activities that we know (from research and common sense) should be avoided during breaks, or at least minimised. In particular, activities that increase **visual** or **mental fatigue**, or increase feelings of **stress** or **pressure**, can prevent recovery. Tasks that are likely to be stressful may cause worry or preoccupation and so can even affect your work before the break. In general, such activities should be done outside of break periods where possible. Activities that may fall into this category include assessments, interviews, important reports, or even difficult conversations. But other types of work which are intense or particularly are also best done outside of breaks. Managers and staff need to arrange additional time for such activities, where possible.

Amber activities

Many activities that are sometimes performed during breaks are often OK in moderation. These really depend on the operational activities before and after the break. In general though, activities should be reduced where they are similar in nature to the operational work, for instance visually demanding, involving a lot of manual inputs, or time-pressured. Let's say you have had a very busy period involving high levels of concentration and lots of keyboard or touch screen work. It would make sense, during the break, to reduce or minimise time spent Internet surfing or completing

Joe, I want to tell you a secret: even I take a break between commercials...
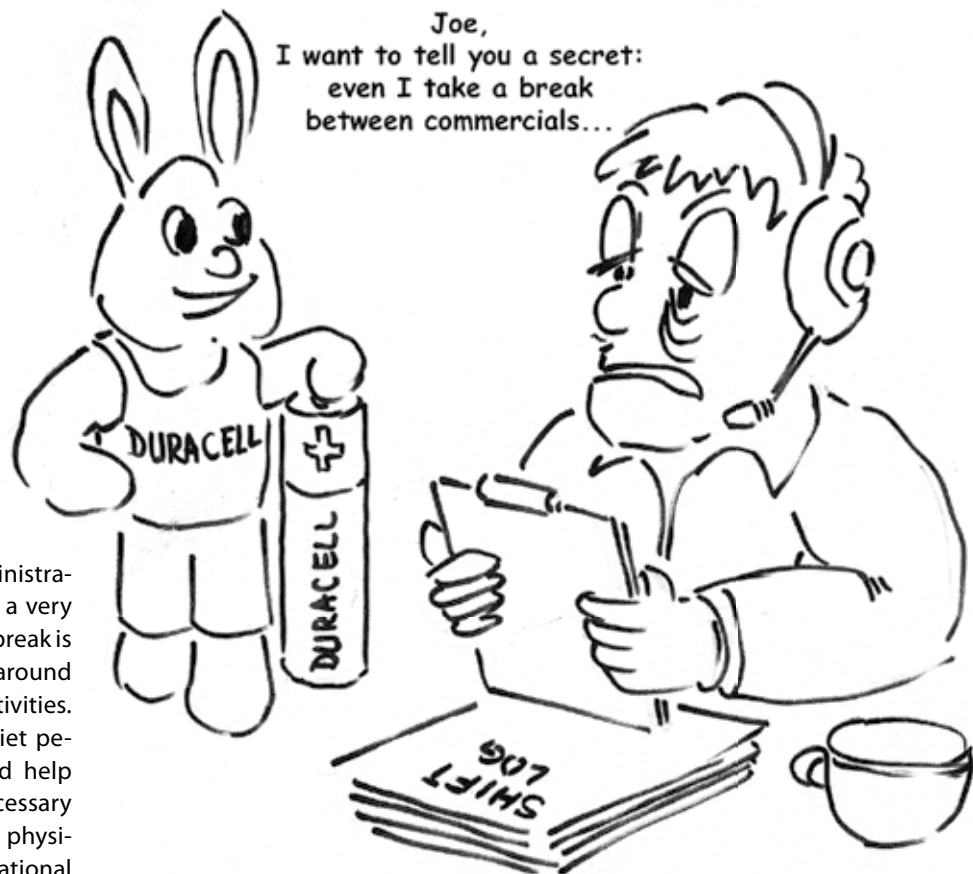
detailed computer-based administration. Similarly, if you have had a very busy session on duty, then the break is probably not the time to rush around doing other time-pressed activities. But if you have had a very quiet period, the same activities could help you re-energise. Where it is necessary to do activities that are similar, physically or mentally, to the operational tasks, it is advisable to take a reasonable period of 'green time' to recover before going back on duty.

Green activities

The best kinds of activities to perform during breaks are usually different to the activities undertaken while on duty. These 'green activities' will allow you to **rest, relax** or **re-energise.** They might include restful or relaxing personal time, social activities, or light exercise. They may be individual to you, but will certainly depend on the nature of the operational work. A period of 'green time' taken immediately before going back on duty, and preferably outside the ops room and away from a computer screen, will help optimise performance.

So when it comes to breaks from operational duty, changes in activity are the key to reducing fatigue-related risks.

Of course, how breaks are spent is only part of the picture. The timing and frequency of breaks are also important and, to a lesser extent, their duration. These broad guidelines would ideally be incorporated in an overall policy or risk management system for fatigue, including provisions for time to perform secondary tasks that may present a fatigue risk. Until then, perhaps managers and operational staff can put the guidelines into practice to help optimise human performance, and maintain safety.

Try to avoid activities that may increase your visual or mental fatigue, or increase feelings of stress or pressure. Such activities should be done outside of rest break periods where possible.

Reduce activities that may prevent you being able to recover from the demands of operational tasks.

Do activities that allow you to rest, relax or re-energise.

An ATC-induced runway incursion

Editorial note: This situational example is not a real occurrence and neither is it intended to be a full description. It has been created to allow a focus on operational safety and human performance aspects.

THE FACTS

Read the story as it develops, position yourself in the context without knowing the actual outcome. How confident are you that you would never get into a situation like this?
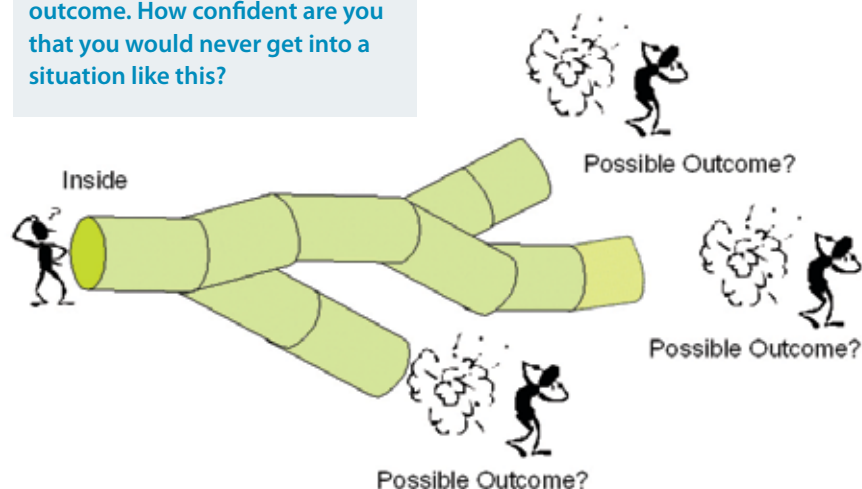
You're a student controller, well advanced in your on-the-job training in the tower of an international airport. Today there are low clouds, with an overcast base that is lower than the tower work floor, so low visibility procedures are in force. Your instructor is also the tower supervisor on this shift.

You're responsible for departures from one runway and arrivals on another runway. The runway axis of the landing runway crosses that of the departure runway, so you have to time the departures to take place once a landing aircraft is safely on the ground but before the next aircraft on final reaches a specified distance from touchdown.

Your "tools" include a traffic situation display on which you can see the aircraft on final, with their distance from touchdown displayed numerically in the labels. You also have a ground radar display, situated to your side, on which you can see aircraft and vehicles on the manoeuvring area. The ground radar shows radar returns only, there are no labels for the targets.

On the ground radar you observe an aircraft decelerating after landing and you clear an aircraft for take-off on the other runway. At the same time you hear an airport vehicle asking for permission to cross the take-off runway with a towed aircraft. This call is received at the position of the assistant controller, which is to your right, and is done on a dedicated frequency for vehicle ground traffic. You tell the assistant that the vehicle and tow will have to wait, and the assistant relays the instruction to wait to the driver of the vehicle. The instruction is acknowledged correctly by the driver.

After the departing aircraft is airborne, which you verify by looking at your traffic situation display, you tell the assistant that she can give the vehicle and tow permission to cross the runway. She informed you earlier that the vehicle and tow are on their way to a platform on the other side of the runway, so you select the appropriate stop bar control button and you switch off the stop bar.

However, there is no indication on your stop bar control panel that anything has changed, and you realise immediately that the configuration of the control panel is not correct.

ATC-induced runway incursion (cont'd)

What would you do?

Rather than reconfiguring the control panel you ask a colleague at another working position in the tower to push the button to switch off the stop bar, which he does. This colleague subsequently takes the initiative to correctly reconfigure the stop bar control panel, so now you have control of the buttons.

You turn your attention back to your traffic. A Boeing 767 checks in at the holding point and reports "ready for departure". Since you know that the vehicle and tow are crossing the runway, you clear the B767 to "line up and wait". The assistant asks you to switch off the stop bar again, for apparently the vehicle driver has reported still being in front of a row of red lights.

What would you think?

This increases the doubt you already have about your understanding of the newly introduced stop bar control panel. At the intersection where the vehicle and tow want to cross there are stop bars on either side of the runway, which can be switched off individually with separate buttons that are marked "west" and "east". But since the runway is 06/24 it always confuses you to think which side of the intersection is west, and which one is east.

What would your next action be?

Your instructor, who was engaged in a discussion with the other controller about the correct configuration of the stop bar control panel, comes up and you propose to resolve the stop bar issue by pushing both the "west" and the "east" buttons. The instructor agrees with this solution, so you push both buttons and turn your attention to your aircraft again.

The call from the B767 a little later that they are aborting take-off because they have a towed aircraft crossing in front of them takes you completely by surprise.

Meanwhile you notice that there is a suitable gap developing in the sequence for the landing runway, so you mentally mark that as an opportunity to let the B767 depart. According to your estimate the runway crossing should also be completed by the time the gap occurs, so all you need to do is wait for confirmation from your assistant that the departure runway is clear again.

You monitor the landing of the aircraft that is at the front end of the gap, and you respond to a call from the next landing aircraft when it reports on the tower frequency. While doing this you hear a call from the driver of the vehicle with the tow on the other frequency at the working position of your assistant. You assume that this call was to report "runway vacated" after completion of the crossing, but you can't get confirmation from your assistant for she is not looking in your direction.

What would you do?

You look at the screen of the ground radar for the position of the vehicle and tow, and you see it clear of the runway at the other side of the intersection. The next landing aircraft is almost at the minimum distance from touchdown at which you are allowed to let an aircraft depart. You're convinced that everything is as it should be, so you clear the B767 for take-off. The call from the B767 a little later that they are aborting take-off because they have a towed aircraft crossing in front of them takes you completely by surprise.

DATA, DISCUSSION AND HUMAN FACTORS

Now read the story knowing the actual outcome. Reflect on your own and others' thoughts about the case, and see how easily judgmental these might get in hindsight. Can you offer an alternative analysis?
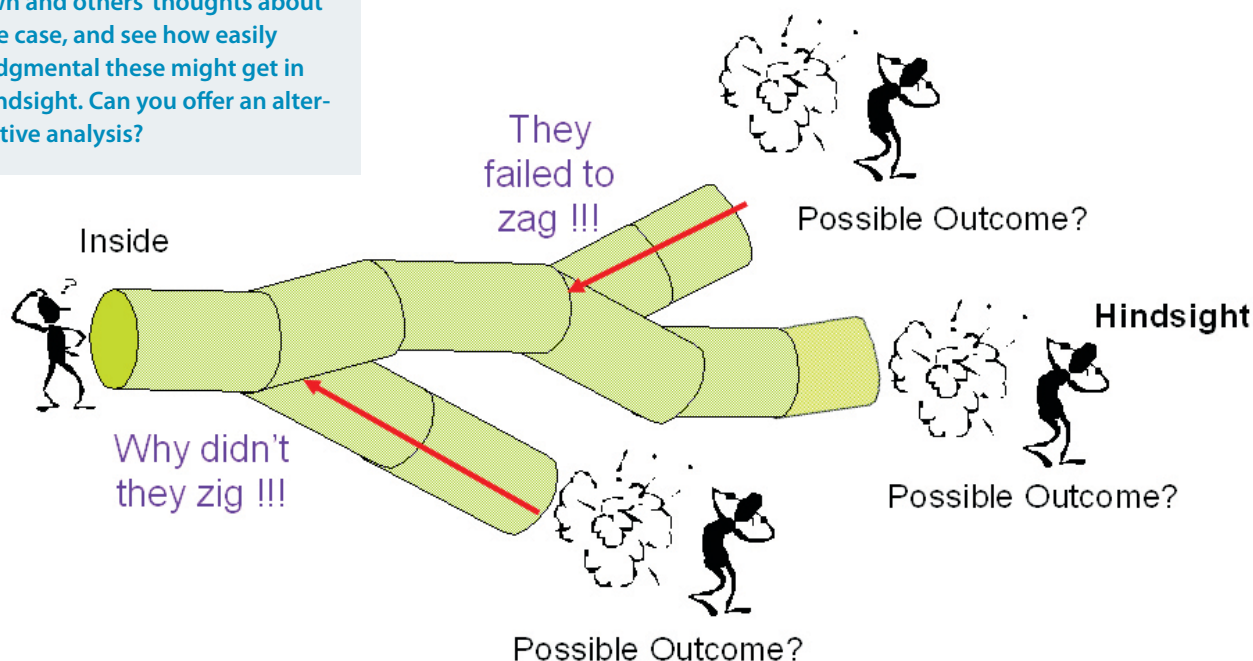
FACTORS THAT WERE IDENTIFIED IN THE INVESTIGATION OF THIS OCCURRENCE INCLUDED:

Human machine interface (HMI) issues.

The assistant controller did not have a ground radar display at her working position (liveware-hardware). She was unable to verify the position of the vehicle and tow when they contacted her to cross the runway. There were displays to the left and to the right of her working position; the one on the left was showing a picture from the terminal radar (for the benefit of the student controller), the one on the right was showing an off-centred ground radar picture (for the benefit of another controller) on which the intersection where the vehicle and tow were located could not be seen. When the student controller tried to get confirmation from her that the crossing had been completed, she was turned towards the screen on her right in order to try and monitor the progress of the vehicle and tow.

This may explain why she didn't hear the student controller issue the take-off clearance to the B767 before she had confirmed that the runway was vacated by the vehicle and tow.

Another HMI issue (liveware - hardware) related to the stop bar control panel. The stop bars at the intersection where the vehicle and tow were crossing had been installed a few months before the occurrence. The buttons by which those stop bars were operated could not be incorporated into the existing panel (with a geographical layout) from which the other stop bars are controlled. It was therefore decided to add a new panel (with a tabular layout) to the side of the existing panel; it was also decided that there should be separate buttons to independently control the stop bars on either side of the intersection.

ATC-induced runway incursion (cont'd)

A further HMI issue (liveware - software) was found in the labels of the buttons on the new stop bar control panel. The stop bars were at either side of an intersection of runway 06/24, which logically means a stop bar on the north side and one on the south side of the runway. The labels on the panel however were "west" for the stop bar on the north side, and "east" for the stop bar on the south side of the runway.

This may have contributed to the confusion of the student controller about which stop bar was the correct one to switch off in order to allow the vehicle and tow to cross the runway.

Training issues

When the new stop bars and the associated control panel were installed, the controllers (including student controllers) were informed about this by means of a "training bulletin", i.e. a written message in which the new items were announced. There was no further introduction or training on how to operate the new panel. The day of the occurrence, with low visibility procedures in force, was in fact the first time for the student controller (and also for his instructor) that the new panel had to be used.

This may explain why the student controller doubted his own understanding of the working of the new panel rather than doubting the information from the assistant about the position of the vehicle and tow.

Procedural issues. When the vehicle called the tower for permission to cross the runway with a towed aircraft, the driver only mentioned the name of the intersection where he wanted to cross. He did not mention his actual position or the direction in which he wanted to cross. The existing R/T procedures didn't require him to mention either of those items, and this had never caused problems before at the airport for at all other intersections the stop bars on both sides were operated with one button on the control panel in the tower.

The call that the student controller mistook as the "runway vacated" message was in fact a call from the vehicle driver to say that the stop bar was finally off and that they had now begun their runway crossing.

The tow movement from the platform during low visibility procedures should have been coordinated between apron control (i.e. the airport authority) and the ground controller (i.e. ATC), but this had not been done at the time of the occurrence.

Recency and proficiency issues. The assistant controller had only returned to operational work in the tower shortly before the day of the occurrence. For the better part of the preceding year she had been a student controller in the approach control department at the same airport, but unfortunately she couldn't complete the training so it was decided to retain her as an assistant controller. She had received only the minimum number of shifts to re-familiarise herself with the work in the tower, and was unaware that during her absence a tunnel under the departure runway had been constructed for vehicles and tow trucks to move to and from the platform without having to cross the runway.

This may explain why she was convinced that the vehicle and tow wanted to cross the runway towards the platform, whereas in fact they were coming from the platform (i.e. the other side of the runway): to her it was logical that a vehicle that hadn't contacted her before could only be on the "terminal building" side of the runway.

On-the-job training (OJT) issues. The fact that the instructor was also the tower supervisor had a bearing on the occurrence. In his role as supervisor, the instructor was occupied in a justifiable discussion with another controller, which took place on the opposite side of the work floor from where the student was sitting. He had briefly moved closer to the student to approve the pushing of both stop bar buttons, but he subsequently moved back to the other side of the tower again.

This may explain why the instructor didn't hear the student issue the take-off clearance before the runway had been confirmed vacated by the assistant.

HERA KEY WORD ANALYSIS

Note: This section is offered as an alternative way of analysing the occurrence. Key words from the Human Error in ATM (HERA) methodology are presented with a brief explanation of how they relate to the occurrence.

Misperception

The student controller switched off the stop bar on the side of the runway where he thought the vehicle and tow were positioned. When the vehicle reported still having a lit stop bar in front, the student controller took that as an indication that his understanding of the new stop bar panel was inadequate, rather than as an indication that the vehicle and tow might be at a position other than that expected.

Expectation bias (1)

The assistant controller expected that vehicles asking to cross the runway had to be on the "terminal building" side upon first contact. She was so convinced of this that she passed on the information to the student controller without confirming the position of the vehicle and tow.

Expectation bias (2)

The student controller was waiting for confirmation that the vehicle and tow had completed the runway crossing. When he heard a call on the frequency for vehicle traffic at the position of the assistant controller, he believed that this was the report that the runway had been vacated even though he couldn't get confirmation from the assistant.

Expectation bias (3)

The student controller looked at the ground radar display to verify that the vehicle and tow had crossed the runway, and he identified them at a position on the platform side of the runway, just where he'd expect them to be after crossing from the other side. This was the confirmation he was looking for so he believed that the runway had been vacated by the vehicle and tow.

Fixation

The student controller was eager to execute his plan to let the B767 depart in the particular gap that he had targeted in the sequence for the landing runway. He therefore didn't consider the option to wait for another gap in order to ascertain that the runway crossing had been completed.

Contextual conditions (in no particular order)

- Low visibility procedures
- Inaccurate procedures (i.e. the vehicle traffic R/T for requesting to cross a runway)
- OJT
- Knowledge for position (assistant not aware of the tunnel under the runway)
- New/recent changes
- Lack of TRM (see below)
- HMI issues
- No equipment (no ground radar display at assistant working position)
- Mode confusion (stop bar control panel configuration)
- Distraction (supervisor/ instructor)
- Adherence to rules by others (no coordination by airport authority about the tow movement)

The day of the occurrence, with low visibility procedures in force, was in fact the first time for the student controller (and also for his instructor) that the new panel had to be used.

ATC-induced runway incursion (cont'd)

Prevention strategies and lines of defence

If the air navigation services provider (ANSP) had introduced a team resource management (TRM) programme, this could have helped the tower crew to function more as a team than as individuals with a narrow focus. Expressing doubts about (the understanding of how to operate) equipment, asking an instructor for help, and asking questions for clarification are things that are only done if the environment for it is right. TRM training makes it easier to establish such an environment.

The ANSP should not require OJT instructors to perform other duties while giving instruction, and have a formal programme for reintegrating operational staff on the work floor after a prolonged absence.

If a safety assessment had been conducted before introducing the stop bars at the intersection concerned, it is likely that the issues with the HMI and the procedures would have been identified and mitigated.

At the time of the occurrence such a safety assessment was not formally required, but as of 2006 ICAO Annex 11 contains a provision that mandates it.

At individual level controllers should be aware of the dangers of assumption.

The assistant controller assumed that the vehicle and tow were moving towards the platform although this had not been confirmed or verified in any way.

The student controller was eager to give take-off clearance to the B767 in order not to "waste" the gap in the landing sequence, so he really wanted to hear that the runway had been va-

cated. When he heard a transmission on the frequency for vehicle traffic at the working position of the assistant, he assumed it was the expected message that the runway was vacated.

In both instances a simple question for clarification would have resulted in certainty about the direction in which the vehicle and tow were moving ("What is your position?") and about the status of the runway crossing ("Confirm the vehicle and tow are off the runway?").

The student controller could have used his ground radar picture to determine the position of the vehicle and tow before letting them cross the runway.

As stationary objects without labels however such targets were not easy to spot on the ground radar screen. With multilateration technology and labels for vehicles and aircraft the newer generation of ground radar displays provides an improved and comprehensive overview nowadays. Still, controllers must have the discipline to look at the picture!

A further line of defence is to inform the pilots of an aircraft that is lining up to wait on a runway that a runway crossing is in progress (or that the runway is occupied by a vehicle) when appropriate.

Whether or not this would have prevented the occurrence from happening is an academic question. In addition to low clouds there was limited visibility at the time, so it's hard to determine whether the pilots would have been able to see the vehicle and tow from the beginning of the runway. The fact is though that in their take-off roll the

pilots did see the tow aircraft crossing the runway in front of them, so they immediately aborted their take-off and brought the aircraft to a stop well before the intersection where the crossing took place.

The strategy mentioned above is also useful in case the vehicle(s) is/are on the same frequency as the aircraft (another line of defence), for pilots may not always be able to correctly interpret everything they hear on the frequency. Never assume that pilots "have the picture" just because communications are on a common frequency!

KEY POINTS

The consequences of a change in the airport infrastructure (new stop bars at an intersection) for existing procedures (R/T for vehicles) and for modifications to equipment in the tower (stop bar control panel) had not been fully understood at the time the change was implemented. Consequently a breakdown in the team work on the tower work floor was possible, which resulted in a situation where an aircraft was cleared for take-off when a vehicle with a towed aircraft was cleared to cross the runway at the same time.

This scenario highlights the importance of:

- conducting a safety assessment before changes in (airport) infrastructure, equipment or procedures are effected;
- team resource management (TRM) principles;
- not assigning additional duties to OJT instructors;
- avoiding assumptions.

Fatigue management in ATC

An important review of work done & work still to be done

We felt that it would be impossible to focus on fatigue and its management in this issue without acknowledging the contribution made by the publication last year of a very thorough literature review and 'next steps' plan by the well-known Mitre Corporation under a US Government contract. This aims to provide a (new) starting point for applied research in respect of controllers. We recommend you take a look at it, but in the meantime, we have asked one of our 'resident experts', **Captain Ed Pooley**, to take a quick look and pick out a few highlights to get you interested"!

Fatigue management in ATC
An important review of work done & work still to be done (cont'd)

In concluding that "the majority of research (into fatigue) fails to adequately address many current areas of concern within the aviation community", it provides a salutary reminder that, despite the arrival of the FRMS approach, we are still a very long way from the bank of scientifically-validated off-the-shelf solutions which need to be integral to any effective FRMS - for controllers or others.

Now, did you know that the FAA already has an 'Office of Fatigue Risk Management'? I didn't. Their definition of fatigue is quoted:

> "Fatigue is a condition characterised by increased discomfort with lessened capacity for work, reduced efficiency of accomplishment, loss of power or capacity to respond to stimulation, and is usually accompanied by a feeling of weariness and tiredness."

Perhaps the rather simpler statement "fatigue can arise from two sources: sleep loss and time on duty" states the obvious rather well.

Anyway, the work reported took a logical three-stage approach:

- A review of what is already known about the effect of fatigue on performance
- The identification of current gaps in relevant understanding
- The development of a prioritised plan to fill those gaps

The Report comes complete with an extensive list of references and a long inventory of appendices which summarise different aspects of the fatigue 'issue' in detail and can be strongly recommended for those who are interested in particular aspects. The ones that caught my eye were the review of subjective and objective measurement of fatigue (Appendix A) and the review of 'sleep disorders' in Appendix B.

The work acknowledges the priority order for a solution-oriented study as US Civil, US Military, other country ATC. It has attempted to take account of non-US work but I suspect that it has probably not managed to capture all relevant work published other than in the English language. As far as Europe is concerned however, it does note 'outreach' to both the Austrian and German Societies for Sleep Research and Sleep Medicine as well as the (UK) Royal Air Force School of Aviation Medicine. Unfortunately, as with similar reliance on peer-reviewed publication, the review seems to have missed some of the ground-breaking work on FRMS in the airline industry when it says, in respect of non-ATC FRMS applications, "FRMSs were either in place or in development in the following lo-

cations and industries: Australia in the mining and medical industries; France in the airline industry; New Zealand in the airline industry; the United Kingdom in the energy industry and in military aviation, and the United States in emergency services (police), nuclear power plants, and the rail industry." Few would fail to acknowledge the real (and successful) efforts to deal with the flight crew fatigue risk at operators such as Singapore and Cathay Pacific.

But to return to what is, despite any shortcomings, still a really useful reference work, I'll talk a little more about the approach taken.

Factors influencing Fatigue in ATC shift work are identified as age, gender and health. So far work on the effects of age is described as having yielded "contradictory conclusions". In respect of health, one quoted study confirmed the intuitively logical observation that those who practice good health habits achieve more sleep and better quality sleep. However, the Report concludes overall that "despite all the research that has been performed on shift work, few conclusions have transferred to operational settings."

Studies of the **Effects of Fatigue** in ATC were found to have been heavily biased towards the effect of shift work on fatigue. By comparison, it was found that comparatively little atten-

'Fatigue Countermeasures' are divided into short-term and structural (FRMS). A good composite summary of simple short-term countermeasures is given:

- Napping
- Avoiding alcohol, caffeine and nicotine 3 to 6 hours before bed
- Limiting alcohol and caffeine consumption
- Obtaining 8.5 hours of continuous sleep each day
- Sleeping in a conducive environment (e.g. appropriate bedding, comfortable temperature)
- Utilising blackout curtains and/or eye masks when sleeping during daytime hours
- Avoiding carbohydrates until the end of a shift
- Consuming healthy meals while working (proteins, fruits and vegetables will increase alertness)
- Avoiding a large meal after work if one is going to sleep soon after
- Stretching regularly (at least every hour) to improve circulation
- Exercising 2-3 before bedtime
- Developing a pre-sleep routine
- Getting to sleep the same time each night
- Utilising mental relaxation techniques to help sleep
- Avoiding sleeping pills
- Awareness of side-effects of medication that may cause fatigue or affect alertness

tion has been given to the effects of fatigue in respect of performance, task complexity and workload. The self-evident fact that night shifts are characteristically worked with less prior sleep than day shifts and at lower levels of 'mental sharpness' is confirmed but when this detail is put into the context of shift patterns, no statistically significant finding that the level of observed operational error favours any one sequence of duties over others has yet emerged. One study is quoted as defining two 'facets' of controller workload the "intrinsic complexity related to the traffic structure" and "the human factor related to the controller's ability and alertness."

As the solution to structural countermeasures, the Report describes an FRMS as a device which relies on "continuous measurements of fatigue risk factors to gauge the likelihood of fatigue and an active culture to derive strategies to decrease either the likelihood of fatigue or reduce the impact of its occurrence".

The gap analysis undertaken by the Review is aimed at "help(ing to) highlight the areas of research that are currently lacking and to encourage a collaborative effort to achieve a broader understanding of the causal factors for fatigue in aviation as well as investigate how these factors in-

teract". The five priorities identified in the Report (in their priority order) are:

(1) Rectifying the coverage of field measurements of fatigue so that they are classified by reference to the type of ATC role being performed (controllers for en route, terminal radar, approach sequencing, VCR or military traffic together with supervisors and a range of support staff).

(2) Validation of measures of controller performance which are sensitive to fatigue.

(3) Research the short and long-term effects of shift work on controllers - the potential effects of personality and age and the effects on cognitive performance, communicative vigilance and situation awareness.

(4) Collection of data to support sleep disorder policy (given that sleep disorders are seen as a major factor in fatigue).

(5) Validation of human performance models to predict controller fatigue.

Do you think these priorities are in the correct order? Personally, having worked quite extensively in mathematical modelling and learnt its limitations as well as its benefits, I think they got No 5 right….

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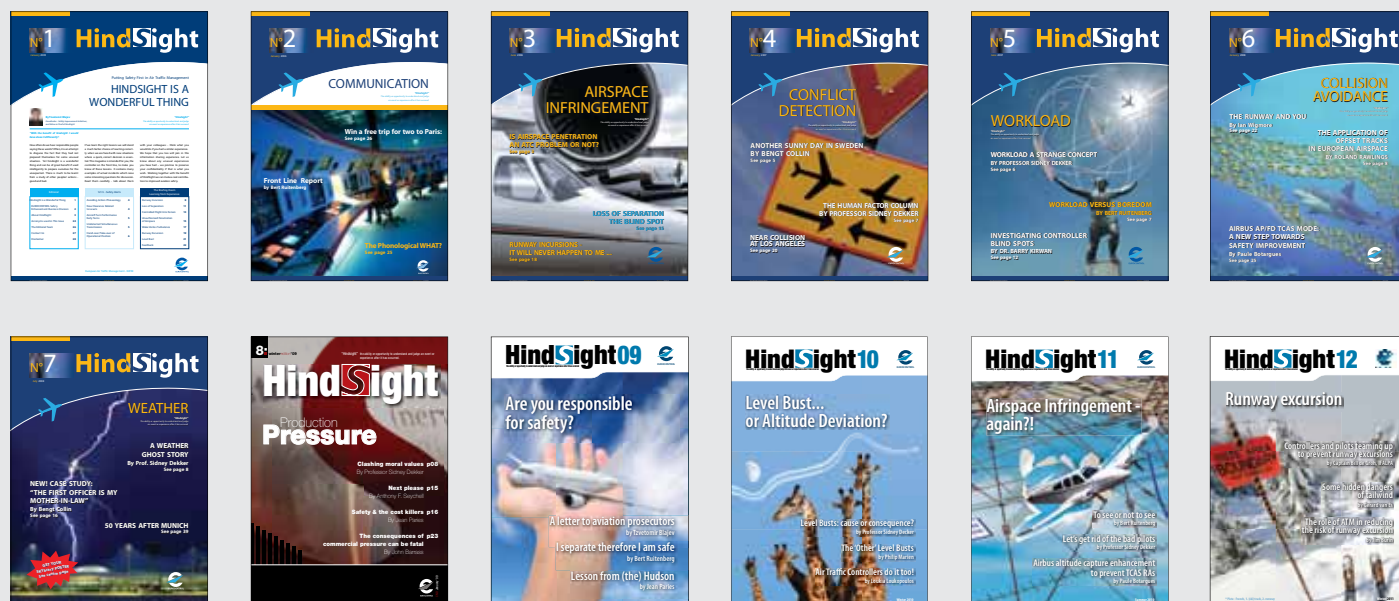
In the next issue of HindSight: Training for Safety

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