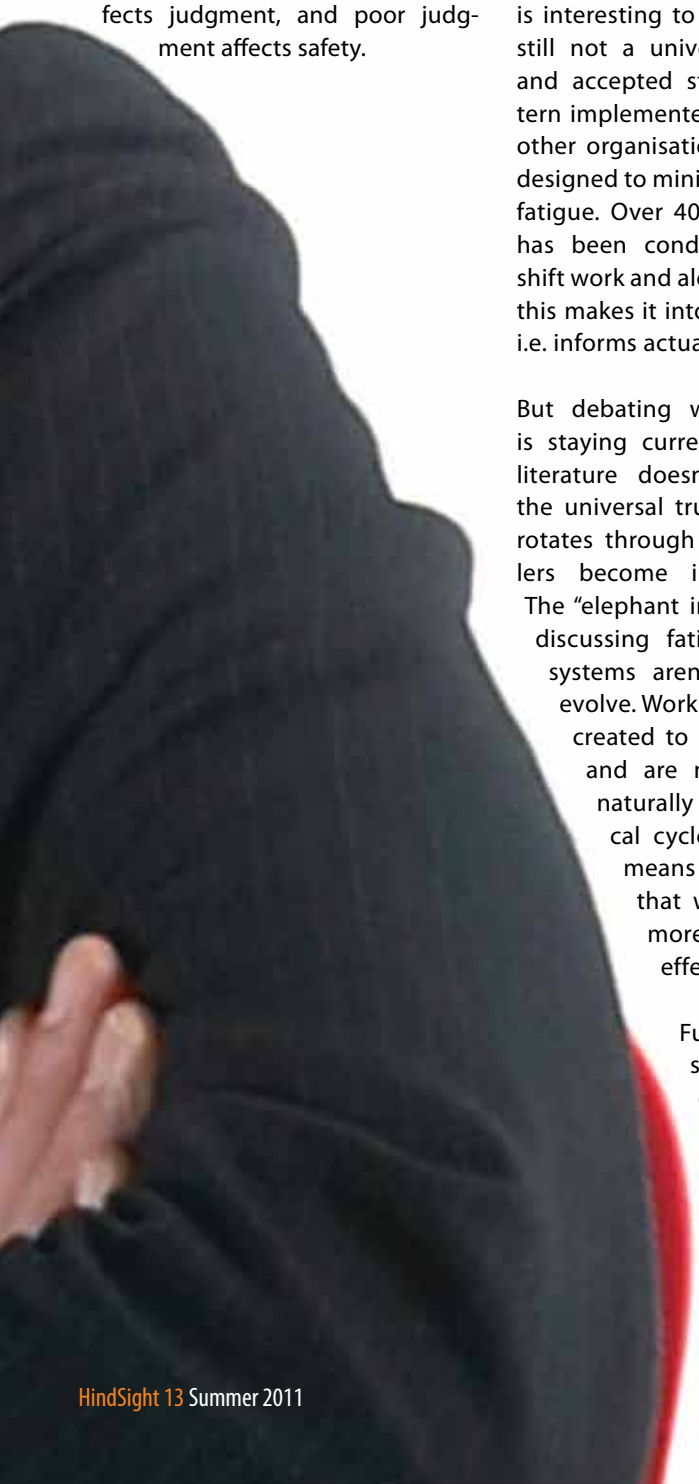
# I know when I'm tired!

**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.

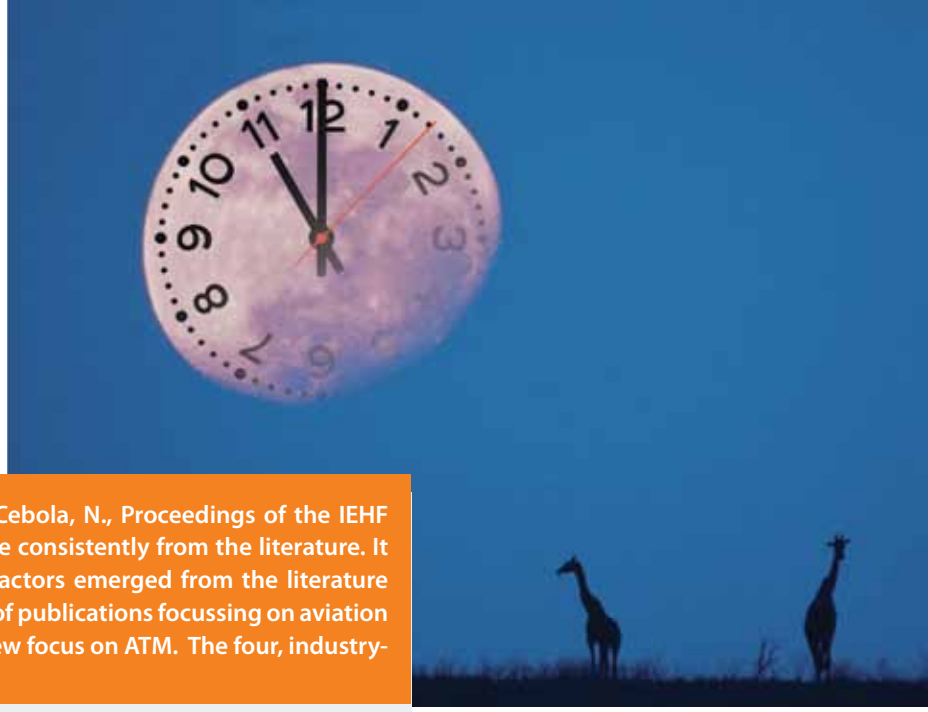
But debating whether an ANSP is staying current with academic literature doesn't really address the universal truth that as a shift rotates through its cycle, controllers become increasingly tired. The "elephant in the room" when discussing fatigue is that shift systems aren't designed, they evolve. 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 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.

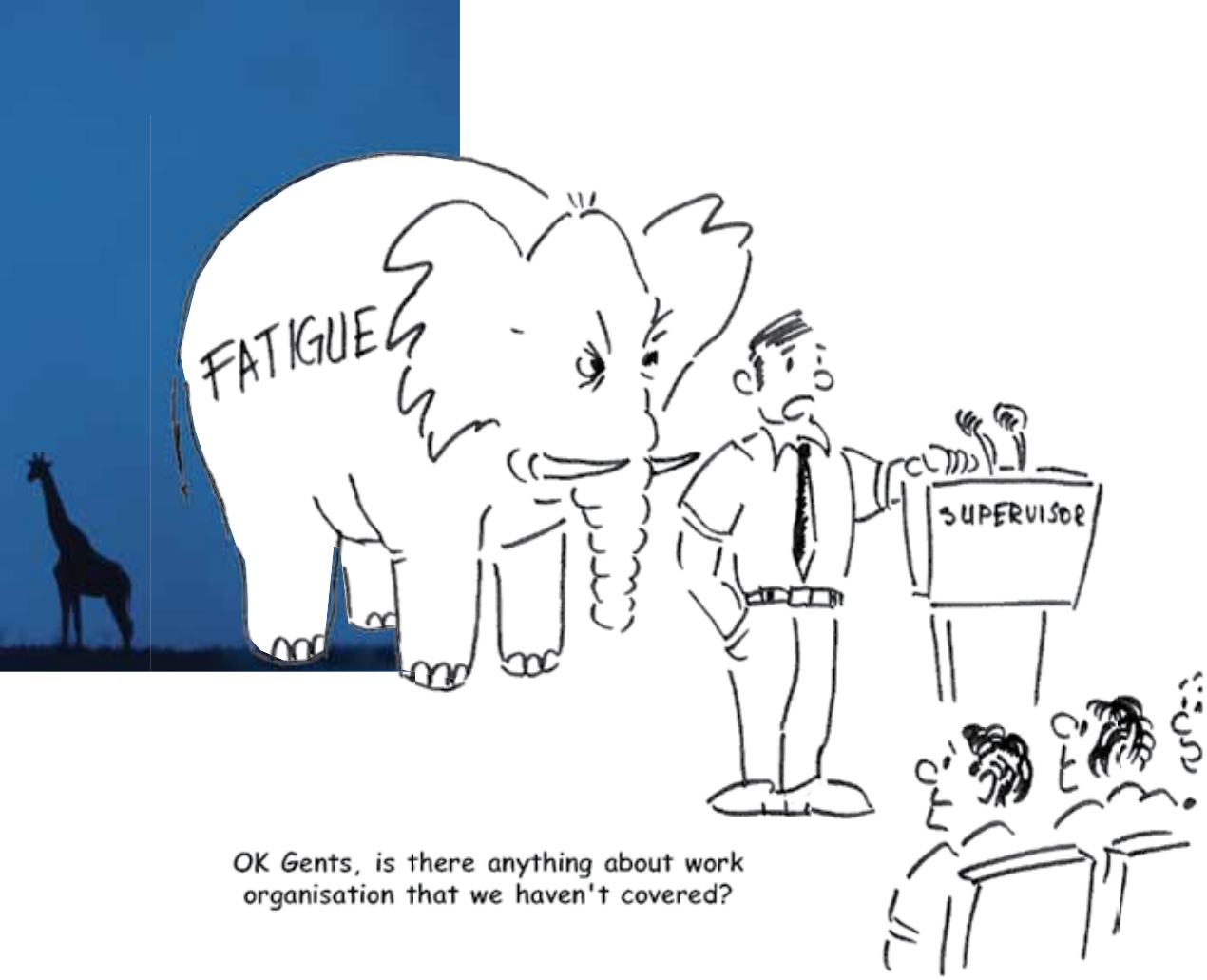
These four factors all combine to provide us with a cumulative experience of fatigue. Unfortunately, how they combine has never been fully explained. No single model of fatigue accounts fully for the interactions, or explains them to any significant depth.

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-




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.