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focus

ON COMMERCIAL AVIATION SAFETY

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FOCUS is a quarterly subscription journal devoted to the promotion of best practises in aviation safety. It includes articles, either original or reprinted from other sources, related to safety issues throughout all areas of air transport operations. Besides providing information on safety related matters, **FOCUS** aims to promote debate and improve networking within the industry. It must be emphasised that **FOCUS** is not intended as a substitute for regulatory information or company publications and procedures.

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Courtesy of, Dan Rosenbaum, Royal Navy Leading Photographer

focus ON COMMERCIAL AVIATION SAFETY

Getting Home...

by Dai Whittingham, Chief Executive UKFSC

The three issues I would like to bring to your attention are perhaps loosely linked but the theme is that of arriving safely at your chosen destination and at the lowest cost.

Lasers are of course a known safety risk, with attacks typically occurring near to the point of arrival. As chair of the UK Laser Working Group I am therefore sad to report the untimely death of the Vehicle Technology and Aviation Bill, which came to a sudden end last month when the Government called a general election, and which had promised to give us a key weapon in the battle against laser attacks. As unfinished business, the Bill had not gone sufficiently far through the system to be short-circuited as part of the 'wash-up' process that occurs between an election being called and Parliament being formally prorogued, and it no longer exists as a piece of proposed legislation. We must start again.

Frustrating though it is to have progress stymied at such a late stage, we are wounded but not out of the fight. The specific measures in the Bill would have made it illegal to use a laser device against the person at the controls of any form of transport. This part of the Bill emerged unscathed from the Committee stage (where all legislative proposals receive detailed scrutiny) and the only adverse comments, from across the political spectrum, were that the measures did not go far enough to deal fully with the laser problem. On that last point, we are in full agreement. Importantly, we have established the principles behind our approach, and there is now much greater understanding of the issues both at political and officials level. We should therefore not have to clear all the previous hurdles to get the matter included in the Parliamentary business programme. It will take more time but, just as with aviation, it is better to arrive late than not to arrive at all.

So let us now look closer to home. The road accident statistics for the UK show consistently that around 25% of all accidents occur within 1 mile of the driver's home, and 50% within 5 miles. The aviation parallels are obvious, with en route accidents being relatively uncommon compared with those at home/destination. Abnormal runway contacts, runway excursions and CFIT accidents on approach all take their toll and, beyond the human cost, all accidents are expensive. And looking even closer to home than the runway, the risks of an accident rise exponentially when it comes to the ramp.

Based on IATA data, the Flight Safety Foundation[1] estimates that 27,000 ramp accidents and incidents — one per 1,000 departures — occur worldwide every year. About 243,000 people are injured each year in these accidents and incidents; the injury rate is 9 per 1,000 departures. There are deaths too, though fortunately not nearly at the same rate. These accidents not only affect airport operations, they result in damage to aircraft, infrastructure and ground-support equipment. Ramp accidents cost major airlines worldwide at least US$10 billion per year at a time when many operators are struggling to remain profitable; as it is not only the major airlines who suffer from ground incidents, the true costs will be much higher.

It is time we started treating arrival and departure from the gate or ramp with the same seriousness that we treat arrival and departure from a runway. It is a key area of risk and, whilst the number of fatalities is mercifully low, the number of injuries alone means we should be taking action regardless of the financial and other costs of these accidents. The ramp is the one area where we put aircraft, engines, vehicles, people and equipment in close proximity and yet there is a bewildering array of differing standards and practices in play despite the availability of ISAGO, IGOM and the like.

The differences are not related purely to nation or type of operation, IATA or non-IATA, FAA or EASA, non-native English or non-English speakers. Many of the problems are of our own making and therefore within our gift to change for the better. As an example of how we have managed to build needless complexity into the system, consider something as apparently standard as ground handling for an A320. At major hub airports such as Heathrow, there will be multiple operators of the same type, many of whom will use the same handling agent. You could reasonably expect the handling agent to have common procedures for the aircraft but the exact service required is specified by the customer (operator), which means wide variations in expectations for all parties. The person in charge of the see-in or dispatch crew must consult tables to work out which combination of aircraft, operator and stand they are dealing with and hence which procedure to apply. That is surely a recipe for disaster.

At an industry level there is, surprisingly, no common definition or common understanding of the term "pushback" – or to be more specific, a common understanding of when a pushback starts and finishes. The most obvious answer to the question relates to physical aircraft movement, but this takes no account of all the activity prior to movement and after it has stopped. And is any forward movement required to complete aircraft positioning considered to be towing, or is it part of the pushback? There isn't even general agreement on whether to chock the aircraft before disconnecting the tug – some do, some don't. Nor is there agreement on whether tug drivers should be on headset and listening for the clearance, or whether it's sufficient for pilots to tell them they have a clearance, or whether headsets are required at all.

Most major airports now track pushback errors as a key SPI, with mechanisms such as pushback without clearance, pushing in the wrong direction, and pushbacks into conflict with taxying aircraft all featuring as sub-sets of the main SPI. But whilst these errors are all a cause for concern, the risks of death and injury rest principally with those ground personnel who are inevitably closest to moving parts, exhausts and intakes. Matters are further complicated by some of the latest engines and the need to deal with rotor bowing (which can require a cooling cycle where the engine is dry-motored). Whilst the risk of being ingested is much reduced, there are legitimate questions about the use of anti-collision lights as an indicator the engine is being started; should dry-motoring be done with the lights off? What additional briefings would be required? The use of anti-collision lights is already widely abused as a means of getting ground personnel to speed up, a form of additional pressure that would rightly lead to protests on safety grounds were it being applied to flight crew. Perceived commercial pressure was probably at the heart of a fatal accident in Mumbai (Dec 2016) when an engineer was ingested by an engine during pushback; the final report has yet to be released.

The Health and Safety Executive in the UK has some long-held concerns about ground personnel approaching the aircraft while it has engines running, and the CAA GHOST has been attempting to resolve the issue by generating an acceptable SOP. However, the increased use of single-engine taxying adds further complexity because there is no common approach to which engine is shut down, leaving ground personnel having on occasions to guess which one is running and therefore the most dangerous for them. Add the general move away from use of APUs (fuel and maintenance costs, noise) and the need to approach the aircraft to connect ground power becomes guaranteed. Whereas it would be unreasonable to expect the industry to back-track on legitimate savings measures, it would not be unreasonable to expect a common approach to mitigating the risks these measures bring with them.

As a final thought on mitigating risk on the ground, it is worth looking at the regulatory framework. Manufacturers must demonstrate compliance with regulations and meet stringent technical standards, aircraft maintenance engineers are licensed, and air traffic controllers and pilots are licensed and subject to regular competence checks. On the other hand, ground handling personnel are unlicensed and their competence and training is largely at the discretion of the handling agent (though most airport operators will set and demand compliance with local standards and practices). Why is such a crucial link in the safety chain not regulated in the same way as the rest of the system? Compliance with an operating standards manual such as IGOM is a step forwards, and licensing will not cure all ills, but surely insistence on some accredited, transferrable common professional knowledge and performance standards would be of benefit?

Last, but not least, in terms of finding one's way home is the issue of navigation. You will be seeing a range of articles and discussions emerging over the next few months in a variety of publications that will air the concept of True North navigation; the first, by the late Paul Hickley of the Royal Institute of Navigation, is in this edition of FOCUS. Commercial aviation relies on inertial platforms for basic navigational functions, and almost every platform also uses a GNSS-based solution for increased accuracy. We have systems that will allow the aircraft and crew to know their location to within a few metres, and then we convert the azimuth outputs to magnetic values based on a database of magnetic variation at lat/long X which can be 5 years old or more. If we were starting to design navigation systems from first principles today, use of magnetic headings is probably not the path we would have chosen; technology has moved on since the lodestone.

We are comparatively fortunate in the UK because we do not have extremes of variation or its rate of change. By comparison, a trip across Australia will see the variation change by 25 deg, and a 200 nm journey in some parts of Canada can see a magnetic heading change by 80 deg to maintain the same true track. Nav Canada has already proposed a move to True North navigation, which makes eminent sense at high latitudes. A global move to True North would eliminate the need for some chart updates, changes to runway designations and changes to associated arrivals and departures. It would also open the possibility of using geo-height, which would fix altimeter settings and free-up much needed airspace as there would be no need for a transition layer. The maritime world has been working in True for 25 years now. Isn't it time we followed suit?

[1] https://flightsafety.org/toolkits-resources/past-safety-initiatives/ground-accident-prevention-gap/

focus ON COMMERCIAL AVIATION SAFETY

Let's make sure we keep on Learning

by Jacky Mills, Chairman UKFSC

Some of the accident and serious incidents we read about come with no advance warning or similarities, but a significant number of others seem to have strangely similar traits as previous events. So are we not learning from these or are there small but very significant differences which offer a completely new lesson to be learned?

Some events seem to occur out of the blue despite best efforts and pre-flight preparation. One of these worthy of review was a Boeing 777-200 on a scheduled passenger flight from South Korea to Dallas Fort Worth. The flight was over Northern Japan at night when unexpected turbulence occurred. Serious injuries were sustained by one of the cabin crew members and nine passengers whilst two other cabin crew and eight passengers sustained minor injuries. Ninety minutes after the turbulence event the aircraft advised ATC that a diversion would be made back to Tokyo.

This flight had departed without the Captain giving Cabin Crew any indication that there may be turbulence in the initial stages of the flight. Indeed, on reaching the initial cruise altitude at FL270 the Captain made a passenger announcement that there was no problem regarding the weather along the intended flight path and extinguished the seat belt signs. The in-flight service in the cabin got underway.

Just after an hour after take-off with the Autopilot and Auto throttle engaged, the Captain noticed a slight rearward movement of the thrust levers. This he recognised as indicative of the potential onset of turbulence and therefore turned the seat belt signs back on. At this point although some cloud could be seen intermittently, the weather radar did not show any significant returns as it was set, so no instructions were made for the Cabin Crew to take their seats. The Cabin Crew checked that passengers had complied with the Seat Belt sign and then continued with the in-flight service.

The flight continued at FL270 in stable conditions with no significant returns on the weather radar for a further 15 minutes until the sudden onset of severe turbulence. The Captain immediately made another PA for the Cabin Crew to take their seats with seat belts on and reminded passengers to remain seated with seat belts secured. In an attempt to get clear of the turbulence ATC were asked for clearance to climb and this was given and commenced immediately to FL340.

However, a second severe episode of turbulence occurred two minutes after the first and this severe turbulence then continued for a further twenty minutes. An hour after the initial turbulence encounter having climbed to FL350 the turbulence ceased.

The cloud top heights in the area were noted to be almost equivalent to the actual flight profile, and given the location of the aircraft in relation to two divergent Jetstreams during the period of severe turbulence, it was considered that it was Jetstream related CAT rather than turbulence of a convective origin.

The Captain contacted the airline head office about the possibility of airframe damage and decided to turn back towards Tokyo, which was accomplished without further event. Despite exposure to prolonged periods of severe turbulence in which recorded vertical acceleration varied rapidly within the range of +1.8g and -0.88g the aircraft was subsequently found to be undamaged.

The investigation focused on what relevant meteorological information had been available pre-flight and the extent to which this had been made available to the flight crew prior to departure. This information was passed to the crew by a contracted supplier with the part of the forecast provided to the crew at the pre-flight planning stage showing that conditions were expected to be smooth at the initial cruise level of FL270 with moderate turbulence likely during the climb to FL350, where conditions were expected to be smooth again.

This recommended climb profile contained no indication of any relevant areas of severe turbulence at any time during the climb. However, 90 minutes before the take-off from Incheon a SIGMET with immediate validity had been issued for Severe Turbulence between FL280 and FL340 after waypoint GOC (Daigo) and 20 minutes after the aircraft got airborne another SIGMET with immediate validity was issued for Severe Turbulence between FL200 and FL270 in the area where the flight was going to be level at FL270. The Flight Crew were not informed of either of these SIGMETs or another one issued by their Contracted Supplier of Met information for this flight just after take-off which forecasted Moderate Turbulence in an area similar to that forecast for Severe Turbulence by the second SIGMET which had already been issued.

In the absence of this updated information the Captain had no reason to commence climb from FL270 at the first indication of turbulence, and after continuing at the same level until the first severe turbulence episode had begun, he then completed the whole climb to FL350 within airspace which was the subject of the first two SIGMETs.

The way in which Dispatchers presented en-route forecast information to the flight crews prior to flight and flight crews' ability to access additional information was found to differ between departures from Company 'hub' airports and all others in a way that made crew awareness less effective. The absence of any update to the in-flight aircraft by data communication was also noted. This situation was considered to have contributed considerably to the risk of exposure to the severe turbulence encountered.

Safety Action was taken as a result of the investigation to 'strengthen the Internet environment in order to enable flight crew members to acquire necessary weather information with portable terminals in all airports which the Company flies into in the same manner as at Hub airports'.

The Probable Cause was 'the aircraft was fiercely shaken because it unexpectedly penetrated airspace with CAT causing serious injury to a passenger and one of the cabin crew'. Also 'the unexpected penetration into airspace with CAT occurred because the Captain and the Dispatcher did not predict the occurrence of the CAT which could interfere with the flight, on account of the method for acquisition of weather information used by the Company.

This salutary tale shows the importance and having all the facts available to the flight crew prior to departure, and once again, how important the pre-flight planning is to the safety of the flight. It also emphasises the potential danger to a flight of severely turbulent air masses and that these can be penetrated with no indications on a functioning Weather Radar. Worth thinking about for sure.

A second event which is worth reviewing occurred in 2013 on a 737-800 being operated on a passenger flight from Burgas, Bulgaria to Pardubice. The flight was being operated by a type-experienced crew with one thrust reverser locked out and made a late touchdown with a significant but allowable tail wind component. The aircraft overran the end of the runway onto grass at 51 kts. No damage was caused to the aircraft and no emergency evacuation was performed. The Investigation concluded that the aircraft had been configured so that even for a touchdown within the TDZ, there would have been insufficient landing distance available. The flight crew were found not to have followed a number of applicable operating procedures.

The aircraft was landing off an approach in day VMC and continued onto firm grass for 156 metres beyond the end of the paved surface to the left of the extended runway centreline. The Investigation found that both of the experienced pilots were performing their duties for the airline company on a temporary basis, and both very familiar with Pardubice, a military aerodrome with approval for civil air transport use. The First Officer was acting as Pilot Flying (PF) for this flight.

It was established that three days earlier the aircraft had been released to service with the right engine thrust reverser deactivated in accordance with the MEL requirement for this action to be taken in the case of an inoperative reverser light. This was placarded as required and the crew were aware. The Estimated Landing Weight was 65,000kg just within the MLW of 66,360kg. ATIS gave a tailwind for the approach to runway 27 which varied but wind checks from ATC gave it within the maximum permitted and all times – FDR data confirmed it remained between 5 and 9 knots throughout.

The runway was wet. Autobrake 2 was selected and 30-degree land flap selected. The approach was stabilised and the aircraft crossed the runway threshold at 46 feet agl before touching down smoothly 821 metres into the runway – with almost a third of the 2,500 metre runway behind the aircraft. The pilots were not convinced that the speed brakes had deployed automatically and so they were selected manually and performed normally. No evidence of any system fault was subsequently discovered and it was considered possible that the two activations overlapped. Both pilots detected a deceleration which was slower than usual and Auto Brake 3 was selected. As the end of the runway approached the Captain took control, selected full manual braking and the operative left engine thrust reverser in what can be described as an attempt to direct the aircraft clear of the approach lighting on the extended centreline.

The aircraft left the end of the paved surface at a recorded ground speed of 51 knots and came to a stop with the nose turned by more than 90 degrees to the left. Passengers were subsequently disembarked via a set of steps brought to the aircraft and then taken to the passenger terminal.

The Investigation noted that various details of the flight crew response once the aircraft had come to a stop, for example not shutting down the right engine until reminded to do so by a ground technician and instructing the senior cabin crew to disarm the slide and open Door 1L prior to the delivery of steps, were contrary to the Operator's SOPs.

The FCOM landing performance data applicable to the landing made was examined and it was found that at the prevailing ELW, a flap 30 landing with auto brake 2 pre-selected plus a 70 kg addition for the inoperative thrust reverser would have required 90 metres more runway than was available even if the touchdown had been made within the TDZ. It was noted that a flap 40 landing in the TDZ with either auto brake 3 or full manual braking would have required only 1,840 metres plus an adjustment for the inoperative thrust reverser. A landing in the 09 direction would have avoided a tailwind component.

In respect of the deceleration actually experienced, it was also noted that the final approach had been intentionally flown 'one dot low' which would have had the effect of delaying the touchdown, especially in the presence of a significant tailwind component. It was also considered that 'braking action might have been influenced by the uneven distribution of the water layer on the runway profile' but noted that runway friction had been tested and found to be above the standardised Minimum Friction Level throughout.

The Cause of the overrun was formally recorded as 'Non-compliance with SOP by the crew and an incorrectly selected landing configuration for an aircraft of the Boeing B737-800 type under the given conditions at Pardubice'.

Five Safety Recommendations were made including that the Airline involved should adopt internal guidelines for monitoring of flight data and compliance with SOPs by their B737-800 crews. Also that the Airline involved should, given the repeated occurrence of similar incidents, review training curricula for flight crew and the methodology for calculation of the distance needed for the landing on contaminated runways. The other recommendations covered training for emergency procedures and disembarkation for all crew, that the airport should review the collection of data of aerodrome movement areas and that CAA & MAA should propose procedures for the measurement of braking action given regulatory changes made by ICAO.

This report is worthy of consideration in the light of FDM data and its positive contribution to flight safety. For the aircraft to have been operated in such a manner it is likely that operations had occurred in a similar manner previously. This is where reviewing FDM data closely can be such a positive part of the safety toolkit. Whilst a lot of FDM data is reviewed using automaton and quite within the intent of the regulations, this could be missing the vital clues that lie within. Events can be triggered in a lower category – maybe labelled only Minor by the system – but give valuable pre-cursor information – and a real clue to a future incident.
Human intervention and close review of data is such a valuable way of ensuring that clues are not left hidden deep down in the data.

SOPs are developed for the conduct of the safest possible operations and FDM data, if used smartly, safeguards this. Being aware if operations are stepping close to the edge of the SOP gives the vital clue of where the real risk may lie. That information that may be a sign that a SOP is hard to follow and is therefore being deviated from, or that a culture shift has occurred possibly by newly employed pilots inadvertently reverting to type when under pressure and using a different SOP. It can also show where environmental conditions at particular destinations make SOP adherence difficult and therefore need addressing at this pre-cursor stage.

It is for the safety professionals to use all the tools available as comprehensively as possible - whether that be the most up to date meteorological information – or digging deep into the FDM data – these are the safety barriers.

Learning from Experience

by Captain Ed Pooley

This year we have passed the 40th anniversary of the aircraft accident which has, to date, killed more people than any other – the collision between two Boeing 747s on the Island of Tenerife in the Canary Islands in 1977[1]...

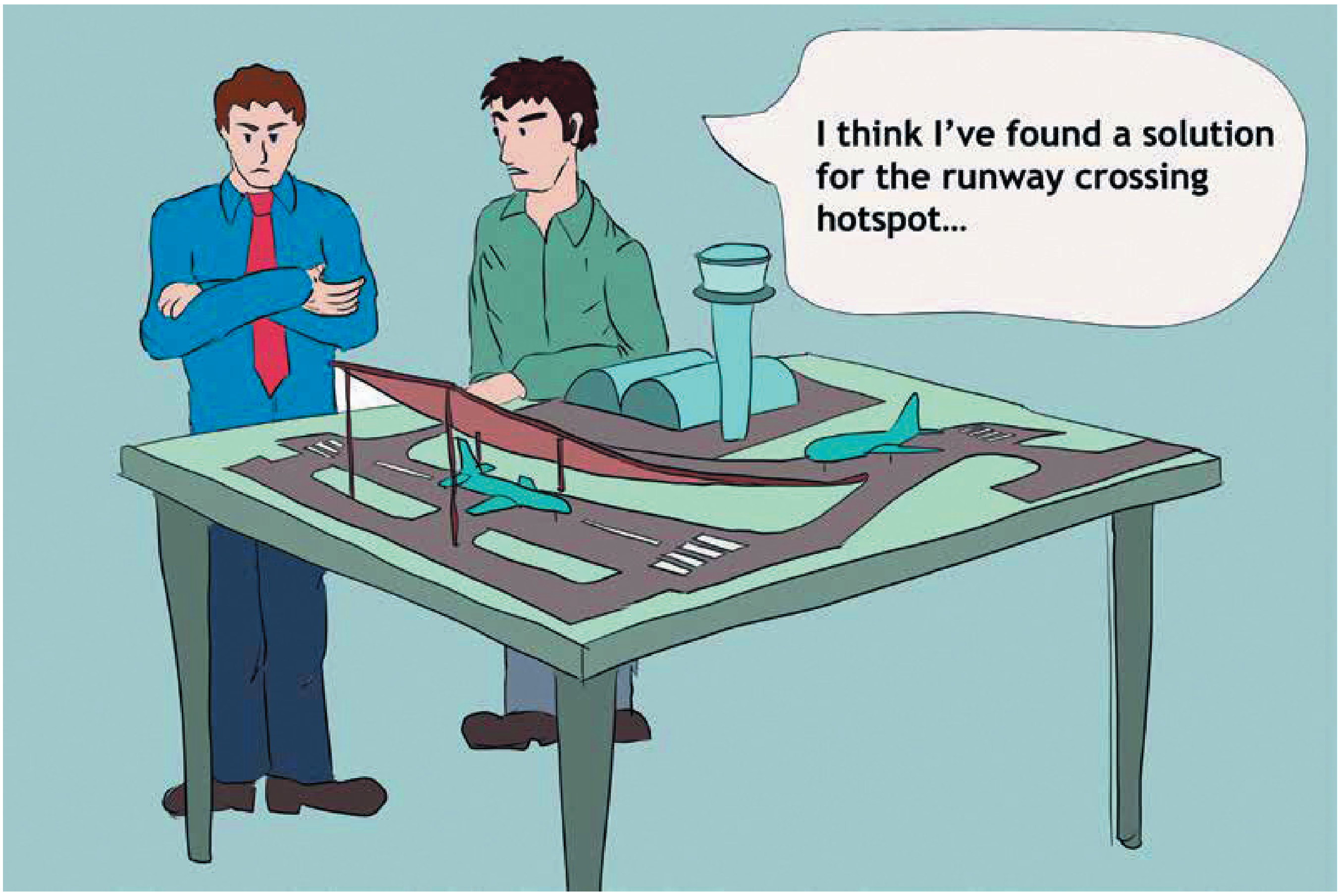
This accident, like all other runway collisions, has its origins in human error, in this case by the commander of the KLM 747 who began take off without clearance in visibility that precluded seeing that the other aircraft was still backtracking the same runway – and may well have been below the minimum permitted given the NOTAM'd inoperative runway centreline lighting. The evidence of the investigation indicated the KLM First Officer working the radio knew that there was no take off clearance but in the circumstances he felt unable to challenge his very senior and highly experienced colleague. Even when the Flight Engineer attempted to alert the Captain to the fact that the radio transmissions which they had just heard indicated that the other 747 was still on the runway, he got an emphatic 'putdown' from the Captain, apparently confident that he did not need help from his crew colleagues.

Since then Captains like this one have thankfully largely disappeared, although I did encounter a few with similar tendencies early in my own flying career. Helped by the Tenerife collision, we gained CRM and embraced the concept of an aircraft commander as a leader accountable for aircraft safety but working with team support of at least one other crew member. We entered a new era in which we began to accept and deal with human factors seriously for the first time. In this respect the chances of a repeat of a collision of this primary origin are very much reduced – but of course never eliminated.

Fourteen years later, a much bigger and always busy airport, Los Angeles, saw another runway collision between two passenger aircraft[2] which also resulted in the destruction of both aircraft and killed 34 people. This time it was in good visibility at night and followed controller error. A Boeing 737 was cleared to land on a runway on which a Metroliner had already been cleared to line up and wait at an intersection a little over 700 metres from the runway threshold. Since then, both the competency monitoring of and support tools available to FAA Controllers have improved a lot – as both needed to, given the situation at many busy US airports at that time. And the FAA design dispensation which meant that the tail-mounted anti collision beacon on a Metroliner which was not visible from the 737 fight deck has since been modified – although not to the satisfaction of the NTSB.

Actual runway collisions involving transport aircraft, especially between two in-service transport aircraft are rare events. But as the 2001 Milan Linate collision[3] between an MD 87 taking off and a Cessna Citation which crossed a red stop bar into the path of the other aircraft in daylight but in thick fog killing all on board both showed, it is speed which is the factor to fear. CRM had arrived on the flight deck of the MD87 but the operating standards achieved by the pilots of the small aircraft which was involved, the like of which often share runway use, were certainly far below acceptable and even the legality of the flight questionable.

Another scenario which nearly led to a disaster at Amsterdam in 1998[4] is towing an aircraft across an active runway when there was an insufficiently rigorous procedure for controlling such runway access. On the day concerned, the TWR Visual Control Room was in cloud but that didn't stop the runway controller assuming that a Boeing 747-400 under tow and not working his frequency had vacated the runway before they gave take off clearance to a Boeing 767-300. Fortunately, the runway visibility was enough for the 767 crew to see the other aircraft in time to stop before reaching it.



The lessons from this event may or may not have since been learned at Amsterdam but they have certainly not been at Jakarta's second airport. On 4 April this year, a Boeing 737- 800 taking off at night in good visibility and in accordance with its clearance collided with an ATR42- 600 under tow without lights which had begun to cross the same runway 850 metres from its beginning[5]. Despite last minute avoiding action by both parties, with the 737 at around 130 knots at impact the two aircraft sustained "severe damage". Fortunately, the airframe contact was between the 737 left wing and the left wing and empennage of the ATR 42 and the fuel-fed fire which broke out in the 737 did not reach the fuselage. No lesson learned from Amsterdam 1998 though, just as then the towing vehicle was communicating with an assistant controller on a different radio frequency. And it's worth noting that an aircraft under tow is likely to be slower moving and less capable of last minute collision avoidance manoeuvring than a taxiing aircraft.

Operations with intersecting active runways bring another form of collision risk. There are two main variants and most but not all of these end up as near misses, albeit sometimes very close and involving premature rotation, delay in rotation or an abandoned take off by one of the aircraft involved. The first scenario has both runways as the direct responsibility of a single controller and the other has separate controllers for each runway. In the USA, liaison between runway controllers has often been a problem whereas this side of the water, the single controller case such as that for intersecting runways 16 and 28 at Zurich has proved difficult to sort out[6]. For similar reasons, many near misses – but few actual collisions – involve aircraft crossing an active runway in order to get to their intended take off runway or from their landing one to parking. Conflict during a taxi crossing of such a runway can have its origins in either controller or pilot error.

An actual collision between a vehicle on an active runway and an aircraft at high speed is rare – but in thick fog at Luxembourg Airport in 2010[7], a Boeing 747-400F making a daylight landing off an ILS Cat 3b approach made superficial contact with a van parked in the Touch Down Zone which one of the pilots saw just before impact. Both the landing aircraft and vehicle runway access clearances were valid but the vehicle had received its clearance on the GND frequency whereas the aircraft had received theirs on the TWR frequency. Lastly, there is the 'simple' incursion case – again with many, many near misses of varying severity but only rare actual collisions – where an aircraft awaiting departure taxis onto the expected runway either having received and accepted a conflicting clearance but failed to follow it or having misunderstood a previously accepted clearance. It is clear whilst pilot error is often involved, the interface between TWR and GND controllers is often involved too.

Now what can we learn from the range of risks exemplified so far and the bigger picture of which they are part? Well, all collisions or near collisions are founded on at least one (and usually only one) human error. That error will have had a context but it will also have had consequences. A lot of effort has been and continues to be put into trying to prevent errors that might – or might not – become the initiating factor in a runway collision and there is still much to be done. But because we can never entirely eliminate human error in setting up this risk any more than we can for other risks, I want to focus instead on how to mitigate its ultimate consequences, the risk of a runway collision where at least one aircraft is moving on an active runway at high speed.

The first requirement is an accurate assessment of airport-specific risk which is free of who is responsible for addressing that risk. The second requirement is processes, procedures and/or equipment which will be effective in preventing high speed runway collisions. That is not necessarily the same as preventing runway incursions even though that in theory will solve the collision risk. I make the distinction in order to advocate a top down approach to risk rather than just a bottom up one. There are many Safety Management Systems out there which get lost in often irrelevant detail and loose sight of the ultimate risks and the priority that managing them demands. Airport users rightly assume, but don't always get, an equivalent level of operational safety.

Of course, the ultimate defence against traffic conflict on the ground is an alerting system based on projected ground tracks/flight paths which is independent of cause and communicates its alert directly to those who will be affected – pilots and drivers. Ideally, this would be a bit like the TCAS ll solution to airborne collision and the alert would be accompanied by guidance on what to do. In reality, we are not yet in sight of that but we do have something which is almost as good – the combination of a Runway Safety Light (RWSL) System[8] and the Final Approach Runway Occupancy Signal (FAROS)[9]. Whilst this FAA-sponsored combi-system ticks most of the boxes and will surely address the runway collision risk at the major US airports where it is being installed, it is very, very expensive and in its present form is only likely to be adopted at busy and complex airports. Some of you may be familiar with Europe's pioneering partial trial of the RWSL element for the main (inner) northerly runway at Paris CDG.

But all is not lost. Airports differ greatly in their complexity and traffic levels and so the route to effective top-down risk management will differ greatly. Incidentally, it is worth noting that there seems to be considerable circumstantial evidence that a disconnect between complexity and traffic levels may, in itself, be a source of avoidable runway collision risk. Where they are well matched, the opposite often appears to be true. Take the world's busiest single runway airport, London Gatwick, for example, where risk bearing runway incursions have long been almost non existent despite 55 movements per hour on a mixed mode runway.

In looking at high speed runway collision risk, it is clear that in all cases, the chances of it are much greater if low visibility and, to a lesser extent, the hours of darkness prevail. There is absolutely no doubt that visual conspicuity has averted many, many potential collisions. It is also generally true that risk is much higher if the situational awareness of those at direct risk is compromised by a failure to have all runway occupancy communications taking place on a single radio frequency and in a single language.

Beyond that, there are a whole set of potential risk factors that could and should be comprehensively assessed at individual airports. All of the following, not placed in any order of significance, have been relevant in the past and may well be in the future too:

- the absence of a process or system to monitor compliance with clearances.
- the absence of a check on the compatibility of all clearances currently valid.
- intersection take offs, especially if permitted from access primarily installed for the rapid exit of opposite direction landing aircraft or any runway intersection which requires less than a 90° turn onto the runway.
- the absence of ground and airborne radar or an equivalent display of traffic positions and tracks available to a runway controller.

- where the crossing of an active runway is necessary on the way to the take off runway or after landing.
- the simultaneous use of intersecting active runways occurs unless wholly effective control procedures are mandated.
- there is mixed mode runway operation.
- pilots are unfamiliar with the airport concerned.
- 'follow the greens' is not used at least at night and in low visibility conditions.
- all runway access is controlled using lit red stop bars operated using strict procedures.
- the runway longitudinal profile is uneven to the extent that a clear view along the length of a runway at surface or near surface level is not possible.
- vehicles permitted to operate airside beyond the ramp area with only one qualified driver on board.
- the procedure for runway configuration change is not adequate or adequate but not always applied as required.
- the procedure for the handover of runway controller positions is inadequate or not followed.
- the procedures for supervision of trainee controllers are inadequate or not followed.

In providing that not necessarily comprehensive list, I do not seek to diminish in any way the concurrent importance of aircraft operator procedures reflecting runway collision risk management at the generic or, where considered necessary, the individual airport level.

Finally, I have one important safety recommendation on this subject. Whilst it is important to understand risk at one's own airport or in one's own aircraft operation, a high speed runway collision or a near risk of it is such a rare event that it is essential to find time to look beyond your direct concerns at what is happening elsewhere.

[1] see http://www.skybrary.aero/index.php/B742_/_B741,_Tenerife_Canary Islands_ Spain,_1977

[2] see http://www.skybrary.aero/index.php/B733_/_SW4,_Los Angeles_CA_ USA,_1991

[3] see http://www.skybrary.aero/index.php/MD87_/_C525,_Milan_ Linate,_2001

[4] see http://www.skybrary.aero/index.php/B763_/_B744,_Amsterdam_ Netherlands,_1998

[5] see http://www.skybrary.aero/index.php/B738_/_AT46,_Jakarta Halim_ Indonesia,_2016

[6] see the findings of one of the more recent investigations at: http://www skybrary.aero/index.php/A320_/_A320,_Zurich_Switzerland,_2011

[7] see http://www.skybrary.aero/index.php/B744_/_Vehicle,_Luxembourg_ Airport,_Luxembourg_2010

[8] see http://www.skybrary.aero/index.php/Runway_Status_Lights_(RWSL)

[9] see http://www.skybrary.aero/index.php/Final_Approach_Runway_ Occupancy_Signal_(FAROS)

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

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Beyond Germanwings Flight 9525: Pilot mental health and safety

by Paul Dickens, Accredited Aviation Psychologist, Core Aviation Psychology

The likely suicide of the First Officer on Germanwings Flight 9525 on the 25th March 2015 and murder of the passengers and crew in the accident has focussed recent attention on the issue of pilot mental health, and its impact on safety. In this article we will look at the resulting regulation changes and some of the issues raised by the accident itself, the findings of the EASA 2015 Task Force and the EASA Aircrew Medical Fitness Opinion 14/2016, issued in December 2016. The issues include:

- The incidence of common mental disorder amongst pilots and its relationship to safe aircraft operation
- The assessment mechanisms for pilot mental health
- Potential issues arising from the identification of mental health issues in pilots, and possible support mechanisms

The regulatory response to Germanwings Flight 9525

After the accident EASA quickly put together a task force to look at the implications including the physical and psychological health of pilots. 6 evidence-based recommendations were made that formed the basis of a rule-making task and subsequent opinion issued in 2016 – see table1.

Table One: *Recommendations of EASA Task Force on measures following the accident of Germanwings flight 9525*

Recommendation 1	The Task Force recommends that the 2-persons-in-the-cockpit recommendation is maintained. Its benefits should be evaluated after one year. Operators should introduce appropriate supplemental measures including training for crew to ensure any associated risks are mitigated.
Recommendation 2	The Task Force recommends that all airline pilots should undergo psychological evaluation as part of training or before entering service. The airline shall verify that a satisfactory evaluation has been carried out. The psychological part of the initial and recurrent aeromedical assessment and the related training for aeromedical examiners should be strengthened. EASA will prepare guidance material for this purpose.
Recommendation 3	The Task Force recommends to mandate drugs and alcohol testing as part of a random programme of testing by the operator and at least in the following cases: initial Class 1 medical assessment or when employed by an airline, post-incident/accident, with due cause, and as part of follow-up after a positive test result.
Recommendation 4	The Task Force recommends the establishment of robust oversight programme over the performance of aeromedical examiners including the practical application of their knowledge. In addition, national authorities should strengthen the psychological and communication aspects of aeromedical examiners training and practice. Networks of aeromedical examiners should be created to foster peer support.
Recommendation 5	The Task Force recommends that national regulations ensure that an appropriate balance is found between patient confidentiality and the protection of public safety. The Task Force recommends the creation of a European aeromedical data repository as a first step to facilitate the sharing of aeromedical information and tackle the issue of pilot non-declaration. EASA will lead the project to deliver the necessary software tool.
Recommendation 6	The Task Force recommends the implementation of pilot support and reporting systems, linked to the employer Safety Management System within the framework of a non-punitive work environment and without compromising Just Culture principles. Requirements should be adapted to different organisation sizes and maturity levels, and provide provisions that take into account the range of work arrangements and contract type.

That Opinion – which is now being considered as changes to the Air OPS Implementing Rules – proposed two changes that derive from the Task Force recommendations:

(1) carrying out a psychological assessment of all flight crew before commencing initial line flying for an operator

(2) enabling, facilitating and ensuring access to a flight crew support programme

Since the publication of the Opinion, and in response to the second of those recommendations, the CAA has issued an Information Notice (IN-2017/005) setting out guidance for operators on Pilot Support Programmes (PSP). This provides a framework for a such a programme that should form part of the Operators Safety Management System, and proposes that any PSP needs to include the following elements:

a) Education on mental health in the aviation workplace
b) Pilot - Peer Assistance Network (P-PAN)
c) Training
d) Wellbeing and health promotion
e) Critical incident support
f) Mitigation of risk of loss of licence
g) Evaluation and feedback

The EASA Opinion is currently with the European Commission to be used as the basis for the preparation of the amended Air OPS Regulation, possibly in late 2017.

Pilot mental health and safety

Pilot suicide itself remains, thankfully, rare. A systematic review of aircraft-related suicides in the United States between 2003 and 2012 reported that pilot suicides accounted for less than 1% of aircraft fatalities. When they do happen, however, media attention is disproportionate to occurrence, particularly in the rare cases that involve commercial aircraft operations. More common are aviation incidents where flight safety has been compromised by mental health issues involving the pilots. Examples include a 2008 incident where an Air Canada co-pilot was forcibly removed from the cockpit and restrained after experiencing a breakdown in flight, and a 2012 incident where a JetBlue Airways captain became delusional, manic, incoherent and physically threatening. The pilot was restrained and the aircraft made an emergency landing.

However severe psychological disturbances amongst operational pilots are also rare, and in most cases transient and susceptible to treatment. There are some exclusion conditions – for example overt psychosis – that stop a licence being granted, but the most common issues experienced during day-to-day operations fall into the category of "mild mental disorder". In some ways these have a more severe impact on flight safety as they will have an impact on the working cockpit environment and the relationship between crew members. A recent Brazilian study of commercial airline pilots looked at the incidence of "common mental disorders" including:

- Non-psychotic depressive symptoms
- Anxiety
- Somatic complaints (headache, lack of appetite, tremors, indigestion)
- Difficulty in concentrating and making decisions
- Forgetfulness
- Insomnia
- Fatigue
- Irritability
- Feelings of uselessness

Findings showed that there was a lower level of each of these compared to the general population, but a higher level when workload and fatigue were factored in. A European survey commissioned by BALPA and carried out by psychologists at UCL used a standard test - the Hospital Anxiety and Depression Scale - and found an increased incidence of, and a positive correlation between, reported symptoms of anxiety and depression and fatigue and work patterns amongst a sample of commercial pilots. My own research, using a standard questionnaire examining mild mental disorders such as anxiety and depression - the GHQ-28 - with a large group of commercial rotary-wing pilots, showed a lower level of common psychiatric symptoms compared to the general population. On the whole pilots seem to be slightly less prone to these mild mental disorders than most people, until the issues of workload, fatigue, the demands of the aviator lifestyle and the operational working environment take their toll. External factors to the cockpit, including financial pressure, relationship and family issues and fear of loss of licence and livelihood, can also lead pilots to be uniquely subject to heavy personal pressures. All of these can have a safety impact – the physical symptoms of heightened anxiety, distractibility, social withdrawal and low self-esteem will have an effect on the performance of even the most technically competent pilots, and will have a similar effect on the crew working environment.

Psychological assessment of pilots

We've seen above that EASA have recommended that flight crew undergo psychological assessment prior to starting line flying with an operator. Psychological assessment of pilots – usually involving psychometric testing – has been around as long as aviation has existed. However a key distinction needs to be made about what the purpose of the testing is. Many operators use psychometric testing as part of the recruitment process – this is generally aimed at gathering information on pilot **aptitude**, and often involves assessing intellectual and reasoning ability, more specific cognitive skills and personality. These tests are usually administered by recruiters or HR staff, and the results usually remain confidential to the recruitment process and are not passed to training or operations managers. EASA stated that a psychological assessment at the level of Part-MED must not be confused with recruitment assessment. In the Opinion they say:

"EASA confirms and further clarifies that the assessment should only assess the personality of the flight crew to ensure a valid prediction of responsible and safe behaviour of the pilot in respect of the work environment. The aim is not to mirror the Class 1 assessments, but rather to ensure that the specific challenges of the operator are duly reflected in the recruitment process."

What is being suggested is more of a **clinical** assessment. However the psychometric assessment of potential mental disorder and ill-health is notoriously unreliable. There are some commonly-used tests such as the ones mentioned in the last section, but their predictive validity – that is how well they pick up psychological issues – is limited and time-bound.

Scoring in the bounds of normality on one day does not predict future issues arising, and particularly in the world of aviation where as we have seen there are specific and unique psychological pressures. A rigorous psychological assessment that meets the EASA intentions will include some psychometric assessment, but will rely more heavily on clinical interviewing and formulation.

There is an evidence base for understanding which personality factors have an impact on safety. The work of Sharon Clarke relating the Big 5 personality factors (extraversion, neuroticism, conscientiousness, agreeableness and openness) to involvement in accidents indicates that safe operators tend to be those people who show higher levels of agreeableness (i.e. they get on well with others and are concerned for other's welfare) and conscientiousness (i.e. they have attention to detail and stick to procedures). However Ray King, a USAF psychologist, has researched the relationship between the personality factor of conscientiousness and unsafe acts in the air. Very high levels of conscientiousness could be linked to a higher level of safety-related incidents during flying because of a tendency to resort to checklists and process when flexibility, alertness and situational awareness are needed. Some assessment of these factors would meet the requirement for a valid prediction of responsible and safe behaviour in command of an aircraft.

Mental health issues and pilot support

Above we mentioned CAA IN-2017/005 contained guidance for operators on establishing pilot support programmes as recommended in the EASA Opinion, with the emphasis on peer support programmes, which operate in many work setting and are based on a shared understanding and mutual respect amongst people in similar situations. The Stiftung Mayday programme that operates in Germany is a good example of such a scheme, and it provides a "safe haven" for pilots in need of emotional support, as well as extending to their families. The programme is sponsored by operators, manufacturers, pilot unions and government but operates independently. The CAA is currently conducting a feasibility study into the possibilities of setting up a similar scheme in the UK. A joint initiative between Stiftung Mayday, the European Association for Aviation Psychology, the European Society of Aviation Medicine and the European Cockpit Association, called EPPSI – European Pilot Peer Support Initiative – has been established and aims to provide best practice information to operators and pilot representatives. The CAA Information Notice highlights some key elements of a pilot support programme including;

a) Education on mental health in the aviation workplace
b) Pilot - Peer Assistance Network (P-PAN)
c) Training
d) Wellbeing and health promotion
e) Critical incident support
f) Mitigation of risk of loss of licence
g) Evaluation and feedback

The programme needs to be part of an operator's SMS, and needs to involve relevant professionals such as psychologists, psychiatrists and AMEs who have aviation experience. The heart of the programme is the peer support network – "P-PAN", which is "a facility for a pilot to contact a trained peer on a confidential basis when they require help, advice or assistance with a developing social, personal or health issue". It aims to provide a first point of contact for pilots who might be experiencing the signs and symptoms of what were described above as common or mild mental disorders, and direct them towards the appropriate level and source of support. In discussion with a number of fixed and rotary wing commercial operators, a number of issues have been raised about how implementing IN-2017/005 will work in practice. These include:

- The issue of confidentiality and anonymity. This is key to an effective peer support programme, but offers challenges to smaller operators with fewer pilots who are often rostered together, may also undertake pilot management roles in addition to line duties, and may also socialise together outside work. Maintaining confidentiality is more difficult in such situations. There is also the dilemma of when and how confidentiality should be broken if there are significant safety concerns about a pilot on the part of a peer supporter. The EASA Task Force identified the maintenance of strict medical confidentiality as a significant factor in the Germanwings accident, and the Opinion sets out ways in which this might be handled, with the maxim "safety overrides confidentiality".

- For smaller operators an issue linked to confidentiality if that of potential stigmatisation of pilot support programme users. A barrier to uptake of the service could exist if pilots are concerned about how well confidentiality will be preserved in a small group of peers.

- The selection and training of peer supporters (suggested to be 1% of the target population) has operational and financial implications for operators, and may be more difficult to resource in smaller airlines. This is something that is being addressed by the CAA in the feasibility study on providing an independent service along the lines of Stiftung Mayday.

- The linkage between an operators' SMS and the pilot support programme is not clear – one is a rules based reporting and assurance system, the other a relationship based system that is more closely linked to human resource systems and policies. The EPPSI Key Elements document suggests that this relationship is one of reporting – including anonymised data on uptake, outcomes such as successful return to flying and relapse rates.

- Clarity will be needed on the extent of the peer supporter's responsibilities and where they might potentially have a role in removing from the flight schedule the crew members that join the support programme without jeopardising confidentiality. The reason why the crew member is removed from the flight schedule must remain confidential. In essence this transfers a management responsibility onto a volunteer with no management role. I can imagine the conversation with a Flight Ops Manager or Chief Pilot that starts "I've taken a pilot off the line today but I can't tell you why....!" An effective pilot support programme will need clear boundaries between the scope and role of peer supporters and flight operations managers, together with appropriate protocols for action where there are serious concerns about a risk to flight safety on the part of a peer supporter working with an individual pilot.

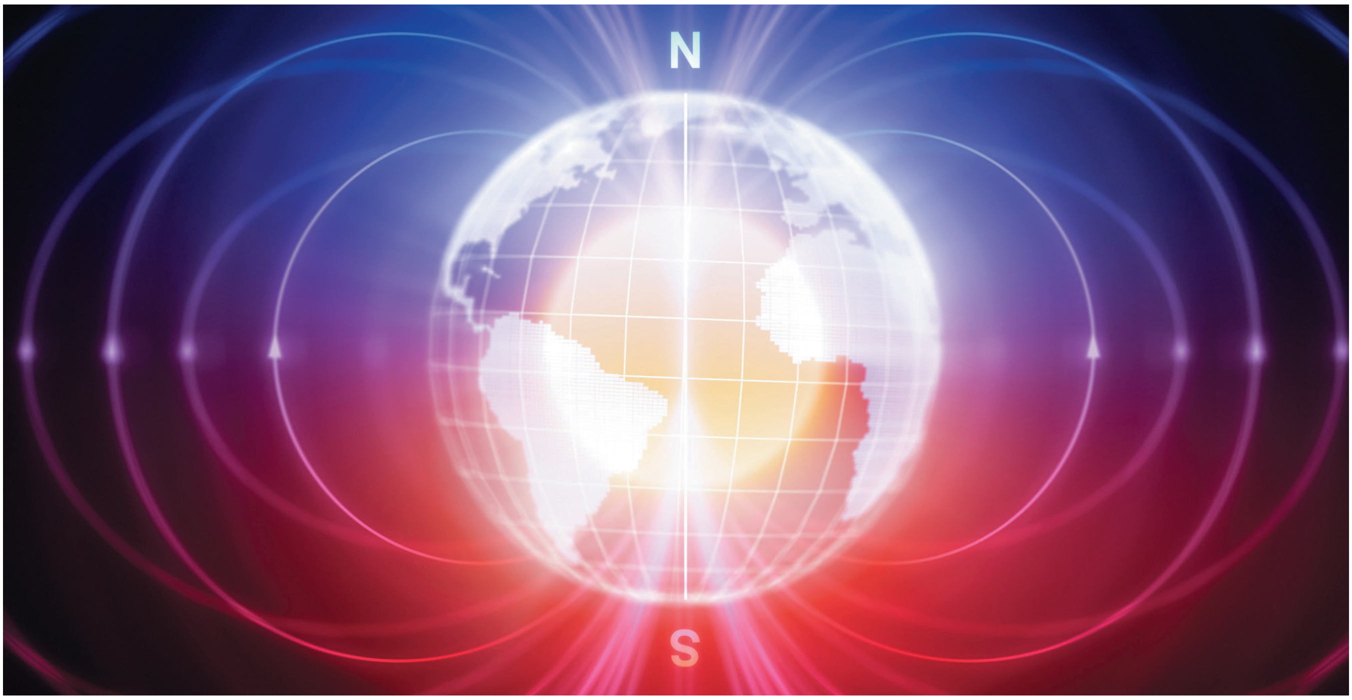
Conclusion

From the tragic outcome of Germanwings Flight 9525 has come an increased realisation of the role that mental health and wellbeing plays in the working life of pilots. Future regulation change will go some way to ensuring this focus is maintained, despite identified difficulties in implementing programmes such as routine psychological assessment and pilot support systems. Such changes will also have implications in other areas of human factors, including the content of CRM programmes as mental health and wellbeing needs to be on the agenda and part of the CRM syllabus with a greater focus on selfawareness and positive steps to maintaining well mental being. Similarly EASA has moved towards increasing the rigour of mental state examination as part of a Class 1 medical. Perhaps the most positive outcome of the Germanwings accident will be pilot's own increased awareness of mental health issues and their relationship to the safe operation of aircraft.

About the Author: *Paul Dickens is a Registered and Chartered Clinical Psychologist and an Accredited Aviation Psychologist with over 20 years experience of working as a psychologist in aviation with individual pilots, manufacturers and operators in commercial and general aviation. He has extensive experience in the rotary-wing sector and specialises in the psychological assessment and support of aircrew. He is the lead psychologist in Core Aviation Psychology – www.core-ap.co.uk.*

Magnetic or True?
The Battle For The Direction Datum

by Paul Hickley of the RIN's General Aviation Navigation Group (GANG)



Credit: iStockphoto.com/Petrovich9

When is a direction not a direction? Practically always, it appears, on a planet with a constantly fluctuating molten magnetic core. That means that there are consequences to using, as we currently do, Magnetic directions for aviation. Paul Hickley of the RIN's General Aviation Navigation Group (GANG) puts the case for a change to True directions.

Here's what might seem a simple question: Why are runway centrelines, airways centrelines and ATC instructions always given in Magnetic direction rather than True? The answer, you might think, is too obvious to need stating: because aircraft compasses give magnetic direction, so it's simpler for the pilot. Well, yes, historically that was the case, but there are counter-arguments. When you measure a track off your topographical chart, it is True direction. Also, more and more of us are using GPS, even at GA level, and any GPS-defined tracks are in True. And, of course, the greatest user of our airspace is commercial air traffic, and any airliner built in the last 40 years or so uses a 'compass' based on True. Agreed, they do also carry a magnetic compass, but it is a small standby one, similar to those found in light aircraft and only used in an emergency. If history were different, and we had invented gyroscopes hundreds of years ago, but had only invented the magnetic compass recently and were now offered it, the aviation world would reject it. True direction can be established from measuring the spin of the Earth, offers operating accuracy of the order of one tenth of a degree and remains constant with time. By contrast, the instantaneous accuracy of a magnetic compass (that is, a snapshot at any random instant) is probably of the order of two degrees. When integrated over a period of tens of minutes or longer, this reduces to about half a degree. More importantly, magnetic declination (or variation, as it is commonly called by aviators) changes with location and time, necessitating constant updating of published procedures.

Earth Magnetism

The usual simple model used to visualise the Earth's magnetic field is to imagine a straight bar magnet running through the Earth, but this is a gross simplification. The majority of the Earth's magnetism is caused because the outer core of the Earth is a mass of molten metal containing significant amount of ferrous ores. The combination of the rotation of the Earth and the convection currents within this liquid creates the geodynamo which makes up the main component of the field. The remainder comes from local magnetic anomalies caused by deposits of solid mineral, mainly magnetite, nearer the surface of the Earth.

The overall effect is more like a bent bar magnet. The North and South magnetic poles are not co-located with the True poles, as defined by the extremities of the Earth's spin axis, nor are they antipodal. For instance, in 2010 the North magnetic pole was at approximately 85N 120W, while the South magnetic pole was around 64S 135E – so far away from the True pole that it is not even on the continent of Antarctica.

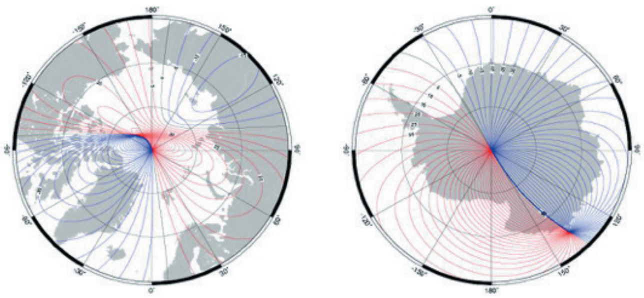


Figure 1 Polar Isogonals in 2010. Credit: British Geological Survey (NERC)

More importantly, these magnetic poles are constantly moving. At Oxford Airport, for instance, the variation in 1942 was 11°W. In 2011 it was 2°W. It had changed 9° in approximately 70 years, giving an overall rate over that period of one degree every 7.66 years. In other parts of the world, the rates of change are different and how fast these rates of change are speeding up or slowing down is also different.

Nobody knows what causes variation to change and attempts to model the changing pattern break down after a certain point because of the complexity of the equations. All that can be done is to observe what has happened in the past and extrapolate into the near future. As with weather modelling, the further ahead we attempt to predict, the less accurate the model becomes.

There are also parts of the world where it is impossible to use a magnetic compass at all. Near the poles, the lines of flux of the Earth's magnetic field take up a very steep inclination to the Earth's surface. The scientific term for this is inclination, but it is normally called the angle of dip by aviators. Close to the poles, the horizontal component drops to less than 6 microteslas, which is the generally accepted figure for the threshold below which a compass can no longer be used. This diagram shows the northern zone 6 microteslas zone and it is evident that it is quite a large one. The one in the southern hemisphere is even larger.

There are also unpredictable changes to variation. Solar flares can be radiated towards the Earth, particularly at times of peak sunspot activity. The time that they take to pass through the Earth's magnetosphere is short – but their effects are noticeable. During the last 11-year sunspot cycle peak, variation anomalies of up to 7° lasting several hours were observed.

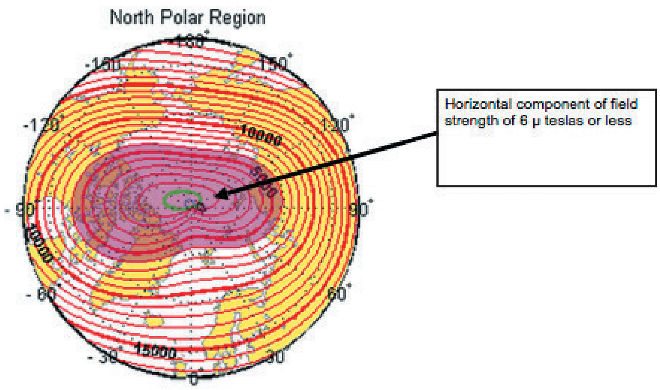


Figure 2 The 6 microtesla contour – North Pole

Current Practice – and Exceptions.

Nevertheless, despite these limitations, magnetic direction is used as the datum for instructions, procedures and control in aviation, including airways tracks, approach procedure tracks and runway centrelines. When the variation alters by more than one degree, it becomes necessary to republish any printed runway and approach documentation. However, runway directions are defined by rounding the magnetic centreline, upwards or downwards, to the nearest ten degrees, then expressing them as a 2-digit figure. 195, for instance, rounded upwards, becomes 200, or Runway 20, while 194 is rounded downwards to 190, or Runway 19. This necessitates repainting the large white numerals on the main runways, and closing the airfield while the work is in progress. Consider the situation at Tampa, Florida, when the runways were re-designated in January 2011. The North/South parallel runway's centrelines are orientated 006.0°T and changed from 36 to 01. According to the FAA, variation at Tampa in 2005 was 4.3°W, with an annual change of about 0.1°W. They should have changed as soon as the magnetic variation was 3.5°W or more, which occurred in 1998. So, even then, the runways should have been designated 01 and 19, but up until 2011, they were 36 and 18.

So why did the airport take 13 years to get round to conforming to what is established statutory practice? One can only surmise, but one of the reasons may be that it had to close for a week in order to re-paint the runways. This would have represented a significant loss of income for such a large airport and they may have put off biting the bullet until they could really leave it no longer.

The other main application in which Magnetic is used as a datum is in those navigation aids where the bearing information is put in at the ground station, that is, VDF, VOR and the military TACAN.

Having decided on this convention, by usage and custom, we then depart from it when it becomes unworkable. At latitudes above 60° or so, tracks and routes published on charts are given in True because of the weakness of the horizontal component of the magnetic field and because it changes so rapidly with both location and time. It is simply assumed that any aircraft operating at high and polar latitudes will be equipped with a navigation system that gives it the ability to operate in True or Grid. Some high-latitude VORs are orientated to True North. Near Resolute Bay, Canada, the variation changes from 10°W to 90°W within about 200 nautical miles. A straight line track on this chart would change magnetic track by 80° in that distance. Everyone using this VOR has to work in True.

Changing to True

Let's now examine how to tidy up this situation. The obvious way is to convert all directions for aviation instructions, procedures and control to True, since we have to use it near polar regions anyway. Let's examine what effect it would have on:

- Airliners
- Aircraft with a gyro-magnetic compass – that is, a good gyro slaved to a magnetic flux valve
- Directional Gyro Indicators (DGI), manually reset to a Direct Reading Compass
- Direct Reading Compass only

Airliners

Any airliner introduced into service less than 40 years ago uses an inertial navigation gyro-based system for navigation. Two, or sometimes three inertial reference systems determine true heading from measuring the direction of the Earth's spin. In the modern Flight Management System, all the navigation computations of spherical trigonometry to calculate desired tracks and all the computations of position data in latitude and longitude are carried out in True, so, for purely navigational purposes, there is no requirement for magnetic direction. Therefore, no magnetic sensor, or flux valve, incorporated into the system.

However, for compatibility with Air Traffic Control procedures, the aircraft have to be capable of operating in magnetic. Thus, the Inertial Reference System contains a database with values of variation against latitude and longitude. Note that this is the reverse of the traditional situation, in which Magnetic heading was sensed and variation was used to convert it to True for navigation. Here, True is sensed, and variation is used in reverse to convert it to a computed Magnetic heading for Air Traffic procedures.

The problem is that variation changes with time. The database is calculated for the half decade in which the IRS was built, ie, built in 1981, set for 1985, built in 1992, set for 1995, and so on. Unless the database is updated, the information goes out of date. Unfortunately, updating is expensive and there is no strong incentive for the airline to carry it out.

It is difficult to establish how often these databases do actually get updated and, clearly, those airlines which allow the data to get out of date will be reluctant to give details of their procedures. However, one airline pilot was so concerned that he took a series of readings over a period of 20 months between 2006 and 2008 in order to confirm what was otherwise merely anecdotal – that the heading shown by the EFIS in his fleet was nearly always a larger figure than the published runway centreline. He was operating in Western Europe and there, with westerly variation reducing with time, the indicated magnetic heading would be too great if the correction database was out of date.

His data is at Figure 3. 364 is quite a reasonable number of observations. The mean is +2.854°, but the mode is more significant, at 4°, especially as he was reading to only the nearest degree. There must be some explanation of why this sample is skewed so well to the positive side of zero and by far the most probable one is that the variation databases were out of date.

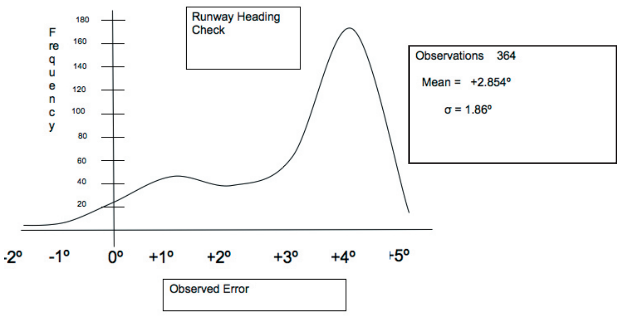


Figure 3 Airline Pilot's Runway Alignment Trial Data. Credit: Paul Hickley

Does this matter? Does it make a difference to safety? For ILS and VOR approaches, probably not, because the aircraft is following a deviation signal against the ILS centreline or the VOR radial, which are paths over the ground and do not change. However, in the ADF, it is the aircraft heading which positions the needle, or its modern electronic equivalent. For an NDB let down, it is a well-established procedure that the descent should not be commenced unless within 5° of the centreline, because the Minimum Descent Altitude is based on terrain within that domain. If the datum heading is 4° out because of the false artificial value of variation, before we start considering any other source of error, it seems possible that safety margins are being eroded.

Additionally, the variation correction system in IRS and FMS is not available at high latitudes. The manufacturers accept that, near the poles, the value of variation is so high and the rate of change is so great, that it would be unsafe to make it available. Therefore at latitudes north of 73°N and south of 60°S, only True headings and tracks are displayed. The magnetic database is inhibited at these latitudes and everyone flies in True.

These regions are becoming more and more important to routine passenger aviation. Thirty years ago, if you needed to fly from Moscow to Vancouver, you would have followed a path at temperate latitudes – something like Figure 4.

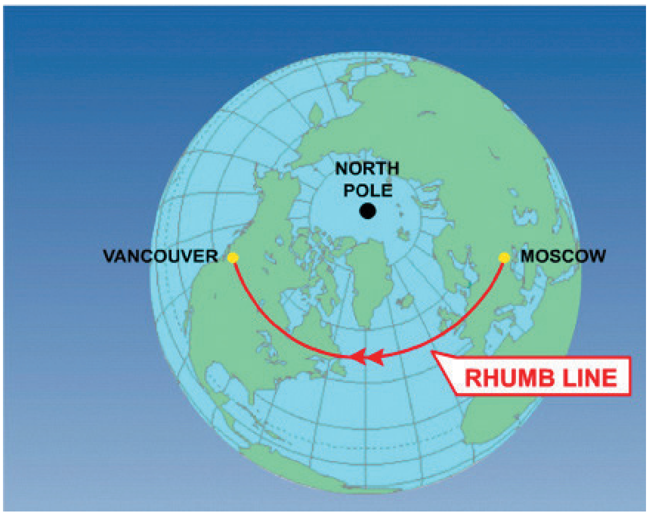


Figure 4 Rhumb Line Track. Credit: OAA Media

These days, your route would be more like Figure 5. Today's aircraft can fly 12 or 13 hours at a time, giving ranges of around 5000 miles in a single leg. They are exceptionally reliable and the chances of an

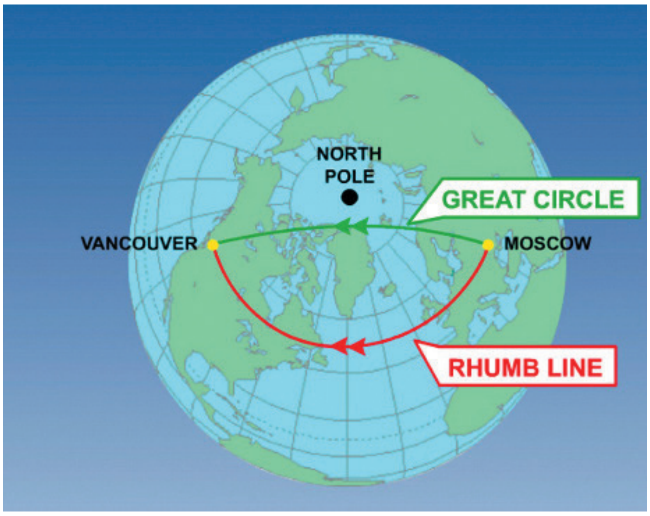


Figure 5 Great Circle Track. Credit: OAA Media

unplanned landing in inhospitable climates are very low. But, more importantly, gyro-based navigation systems allow us to navigate across the pole, saving thousands of miles on some journeys.

Aircraft With A Gyro-Magnetic Compass

Let's now turn to those aircraft which use a traditional gyro-magnetic compass in other words, one with a flux valve, such as might be found in an air taxi aircraft.

In fact, this problem of operating gyromagnetic compasses in True has been dealt with before. During the Fifties and Sixties, compasses were magnetic but automatic dead reckoning systems using

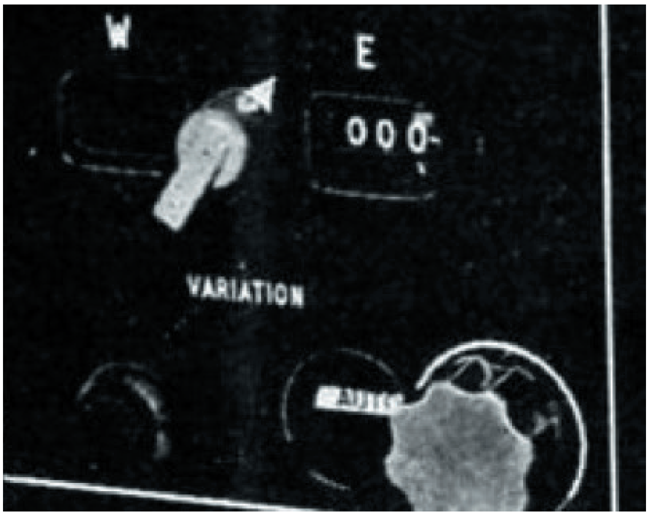


Figure 6 Manual Variation Setting Controller. Credit: MOD

Doppler needed their input to be in True, to be compatible with a latitude and longitude graticule. Most compasses for large aircraft of that period had a facility for manual entry of variation to give a true read-out to the navigation equipment and, in many cases, to the actual compass dial, so that the pilot could fly True headings off the compass.

This facility tended to die out in gyromagnetic compasses produced after about 1970 because the Doppler Ground Position Indicators had become digital by then and it was simpler to adjust the variation in the display computer itself, not the compass. However, if we switched to True, the demand would revive, and it would be an easy matter for manufacturers to reinstate a well-established fifty-year old technology into modern gyromagnetic compasses.

Directional Gyro Indicators (DGI)

We now turn to those aircraft using a combination of Direct Reading Magnetic Compass and a Direction Gyro Indicator. These present the smallest problem of all. The DGI has no direct magnetic input and is simply set by the pilot to whatever datum is required. Normally, this is magnetic direction. All that would be required would be that the pilot would have to apply the local variation every time they reset the DGI, which is normally every fifteen minutes or so. The light aircraft community has nothing at all to fear from such a change.

Direct Reading Compass Only

For aircraft which have nothing but a magnetic compass, which is mainly the microlight community, the only real option would to mentally apply variation. Generally, these aircraft tend not to fly much more than, say, 100 miles from their home bases and it is a simple matter to remember just one value of variation and apply it every time.

VORs

The variation at a VOR is set at the ground station. It can be altered easily by changing the reference signal and, in fact, it has to be adjusted every time there is a variation change at present. The facility is already there to change it from Magnetic to True North. Once set, unlike the present situation, it would not need to be moved again. In fact, within the UK, any change to the VORs will require less work than it would have done previously. NATS propose to reduce the number of VORs within the UK from 46 to 19 over the next 7 years. Clearly, they believe that all commercial traffic is now fitted with some form of area navigation equipment and that a large number of private pilots have GPS.

GPS

GPS establishes position in latitude and longitude, which is based on True north. Because of its extreme accuracy, by integrating successive fixes over a short time interval, it calculates True track, which can either be displayed in numerical form or as a track marker on a moving-map display.

Figure 7 Typical Moving-Map GPS Display. Credit: Airbox

This particular model cost about £160 when launched, which is about the cost of one hour's light aircraft flying. These days, you don't even need to buy the device – you simply download the app to your iPad. It is actually cheaper than a simple Direct Reading Compass. Given that True track is now available at this sort of price, why would anybody want magnetic heading, except possibly as a standby in the event of a power failure?

The Case for Converting to True

The case for converting to True as the datum for aviation instructions, procedures and control is clear, and the only problems would be those of practically implementing it. The biggest single problem in trying to implement this change worldwide would be inertia – the large number of countries involved and the difficulty of finding the will to all change at once.

Some of these countries do not have a sophisticated aviation environment which could deal with this easily, and in others, such as the United States, the sheer extent of the change would be formidable and might meet opposition from a conservative general aviation lobby. Probably the only way that it could happen would be if a single country were to file a difference with ICAO and change unilaterally. Once they had proved that it worked without problems, we might then expect others to follow progressively.

This is not as unprecedented as it sounds. Some countries use feet for altitude, others use metres. Some use hectopascals, others use inches of mercury, and so on. There is no difference in principle if some were to use Magnetic and others to use True.

In fact, one country has already taken a lead. The rate of variation change, both with time and position, are so great in parts of Canada that, at the 12th ICAO Conference, held in Montreal in November 2012, NAV CANADA, the agency that owns and operates Canada's civil air navigation system submitted a working paper which reported as follows:

4.3.5 Navigation with reference to True North only.
NAV CANADA continues to investigate only the use of navigation referencing True north for aircraft operations. A significant effort is expended to update current aeronautical information with changing magnetic variation (MAGVAR). Modern avionics carry out navigation calculations with reference to True north, and then convert the information for pilot displays to Magnetic (by applying a magnetic variation based on a magnetic model), or True heading or true Track, depending on aircraft capability). Safety activity in recent months include the emergency repainting of runways as a result of lapsed MAGVAR data and the cancellation of all CAT 1 through III approach because of a changing MAGVAR, and out of date MAGVAR reference tables on board the aircraft (as old as 2005) in some states. NAV CANADA believes all operations referenced to true north would enhance the overall safety floor and save considerable effort in maintaining MAGVAR tables.

The paper concluded with the following recommendation (some other recommendations, not relevant to this topic, are omitted from the quote below):

6.2 The Conference is invited to agree to the following recommendation:……. That the Conference request ICAO to:……..

……..consider employing navigation with reference to True North as the standard reference.

RIN takes the view that the case for converting to True as the datum for aviation instructions, procedures and control is clear, and the only problems would be those of practically implementing it. While it would be a huge and costly undertaking, it would also be a one-off operation which, once completed, would be final, unlike the present situation which is also costly, but is constantly with us.

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The problem of many imaginations

by Suzette Woodward

Healthcare often looks to aviation to learn about safety, but the two fields are fundamentally different in many ways. Healthcare is innovative, with many highly skilled front line professions who often favour clinical judgement over standardisation. This can bring a 'problem of many imaginations', as Suzette Woodward explains.
When you read ths article, look for the parallels with Captaincy and Management.

Key Learning Points

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

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

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

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

So we have transformed healthcare from these early days to an astonishing industry that improves the lives of many. This is through a constant challenge of the status quo. Innovation and improvement is in our genes, it is at the very heart of what we do. We try to do the very best for our patients while constantly moving healthcare forward.

An early innovator Florence Nightingale, who is clearly known for being at the forefront of nursing and nurse training, was also one of the earliest patient safety thinkers and statisticians. In the mid-1850s she noticed that many of the soldiers were dying in ways which she intuitively thought were avoidable. She plotted all of the reasons why soldiers died in the army in the Crimean War from April 1854 to March 1855 and found that most of the soldiers' illnesses were caused by what she describes as 'defects in the system'. She deduced that perhaps at least one in seven of the patients (around 14%) died from preventable diseases rather than their battle wounds. As a result of this work she made huge improvements to the way the soldiers were being cared for. These were not isolated interventions but fundamental aspects of care; good nutrition, warm clothing, and good ventilation, and most importantly cleanliness and hand hygiene (Woodward 2017).

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

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

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

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

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

A second problem concerns variation between actors. Clinical judgement is used as an excuse for variation: 'I'm doing it my way'. This variation is a significant risk to patients. Clinicians believe that they have a right to autonomy above all else. This means that one surgeon performing a tonsillectomy can carry out the procedure in a very different way from another surgeon doing exactly the same thing, even within the same hospital. It also means that rather than see all doctors and nurses as equal and feel safe in everyone's hands, patients instead ask 'who is doing my operation today'. There is an intrinsic desire to reject rules and regulations that clinicians feel may prevent them working differently from others.

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

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

In summary:

- There are too many ideas, guidance and findings.
- There is too much unnecessary variation.
- There are too many local solutions.

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

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Achieving peak safety performance: listening and learning

Organisations need to be confident that they are hearing all the safety concerns and observations of their workforce. They also need the assurance that their safety decisions are being actioned. The RAeS HUMAN FACTORS GROUP: ENGINEERING (HFG:E)† set out to find out a way to check if organisations are truly listening and learning.

Accountable managers and senior executives are increasingly reliant on their organisation's Safety Management System (SMS) to help them make sound safety decisions and to implement their decisions. As part of a move to Performance Based Regulation (PBR), the UK Civil Aviation Authority now also has 'conversations' with accountable managers on their organisation's risks and safety performance.

Organisations that aspire to peak safety performance need a heightened awareness of two things: the warning signs of impending threats and their opportunities to improve. They need a reliable organisational ability to 'listen' for warning signs and opportunities, analyse their significance, learn and crucially, to promptly act on that learning. To do this effectively they must engage everyone in their organisation, meaning that effective leadership is vital too.

They say 'safety is no accident' but, as commercial aviation accidents become rarer, having had no recent accidents does not mean an organisation is 'safe'. So how can accountable managers and senior executives prove to themselves that they have listening and learning organisations? The RAeS HFG:E set out to answer this question.

The traditional approach would have been to deconstruct the components of ideal SMS (typically from a regulatory requirement or an industry standard for SMS), create a checklist and do an audit. During that audit one might even grade the maturity of the components as present, suitable, operating and effective (for example). While this conventional approach has value, it also has three limitations. Firstly, it is structured around compliance with predetermined practices. Secondly, it doesn't actively encourage innovatively creating future best practices. Thirdly, it focuses on processes and procedures yet, as highlighted in the *Haddon-Cave Nimrod Review*, people make safety, not just processes and paper.

The RAeS HFG took a different approach. They choose to develop ten performance-based questions, organised in three themes, to prompt reflective thought. As well as self-reflection, they can be used as discussion topics in safety meetings and workshops, or as part of safety leadership coaching.

Identifying the warning signs and opportunities:

Q1 How do you know that employees are confident to confide their concerns, report occurrences, reveal human performance issues and suggest improvements?

Are you getting a true picture of your organisation's operations and threats? Do your people trust the reporting and investigation processes, enabling them to be open and honest? Are they motivated to continually suggest improvements? Consider:

- How much time do your managers and supervisors spend with their people, talking about safety and encouraging a dialogue?
- How do you know that your people understand their responsibility for safety?
- How do you show you are committed to a just culture and how confident are you that this commitment is understood by your people?
- How well do you maintain trust through your investigation process? Are your HR policies and processes aligned with your safety policy? Are investigations primarily aimed at systemic improvement?
- Does your SMS capture the general feeling of your people on safety matters?

Q2 How does your organisation react to 'bad news'?

A strong safety culture is one in which everyone, especially senior executives, are ready and willing to hear bad news. In such an organisation no one denies an ugly or inconvenient truth, shoots the messenger or mistrusts the reporter's intent. Stay open minded and non-judgemental, listen for understanding and opportunities for improvement. Consider:

- Do you welcome bad news as an opportunity to improve or as a way to identify who is at fault?
- Do managers go to see for themselves and talk to the right people before acting?
- Are managers open and inquisitive, willing to listen, learn and change?
- In your organisation, is it normal to aspire to be a leader that nurtures, enhances, enables and empowers?

Q3 How do you ensure that it is easy for employees to raise concerns, report occurrences, reveal human performance issues and suggest improvements?

Effective reporting and employee engagement are key components of your safety system. Are your processes sufficiently flexible to capture and highlight safety concerns and improvement opportunities in varied situations, in a timely manner? Consider:

- How wide is your range of reporting methods (eg verbal, paper forms, IT network, web or app)? Does everyone have easy access to one or more of these methods?

- In practice, are these simple and easy to use?
- Are you sure your people understand what needs to be reported? How well do you train and promote this? Are they given the time to complete reports?

Analysing the significance of warning signs and suggestions

Q4 How do you ensure that your organisation appropriately analyses its safety data?

You may gather much safety data in many forms but how well do you turn that into actionable 'intelligence' to improve your processes and reduce risk? Consider:

- What safety-related data do you gather (or could you gather)?
- How well does your organisation collate that data, analyse it, monitor for changes and share those insights?
- Do you routinely use this data to update your risk assessments and procedures?
- How many of your organisation's safety decisions are based on solid data and how many times do you lack the critical information you need?
- Are you able to routinely use safety data preemptively or are you mostly using data only after occurrences?
- Do you actively search public domain sources and participate in industry safety groups to supplement your internal data?

Q5 How deeply does your organisation consider what prevented 'near-misses' from becoming accidents?

Holistically investigating near-misses can help you understand and reinforce what went right, by design or coincidence and how you were protected against a more severe outcome. Consider:

- Are near-miss reports systematically investigated, analysed and risk assessed?

- Do your investigations look for what went right, as well as what went wrong?

- How do you determine 'how close' near-misses were to an accident?

Q6 How can your organisation get more safety insight out of the corporate data it collects?

When monitoring your safety performance and making safety decisions, are you relying only on the safety department's own data or do you look at all corporate data as potential safety data? Consider:

- Are you fully exploiting audit reports, entries in maintenance records, reliability data, parts usage data, planning/production/project management data, supplier performance data, competence assessment records, training feedback forms, overtime records, employee retention data, customer complaints, warranty claims, meetings actions etc?

- Are you combining data from multiple sources or are you limited by how you record and store data (ie by data silos)?

Q7 How well do you monitor your top risks with Safety Performance Indicators (SPIs)?

The use of appropriate leading and lagging metrics can help measure performance, anticipate the future and proactively prevent problems from occurring. Consider:

STAYING ALERT: MANAGING FATIGUE IN MAINTENANCE

Maintenance personnel fatigue is a topic that has featured in several recent air accident reports. Successfully managing fatigue is a major safety opportunity. The RAeS HFG:E held a conference at Cranfield University on 9 May 2017 on staying alert during maintenance. The one-day conference featured both presentations and interactive workshop sessions.

- How well do your SPIs provide assurance of your safety performance?

- Do your SPIs provide you with early warning that critical safeguards are deteriorating so timely interventions can be made?

- Do your SPIs cover your top risks and critical controls?

Q8 How confident are you that your organisation has accurately identified its top risks?

To make informed risk-based decisions requires an understanding of the hazards that your organisation is exposed to, their potential severity and the likelihood. How complete and accurate is your organisation's risk picture? Consider:

- How do you collect information to help you understand and prioritise your organisations greatest threats?

- Worst case consequences can be relatively easy to imagine but likelihood can be much more difficult to estimate. Do you have the right data to make confident estimates?

- Has your organisation the appropriate skills and tools to understand risk?

- Do occurrences validate your existing risk assessments or are they sometimes surprises?

- How often do you re-examine all your risks? Do you only look at a narrow sub-set?

Taking action: learning, improving and leadership

Q9 How do you ensure learning and improvement is achieved across your organisation?

A learning culture is one which processes information in a conscientious way and makes changes accordingly. Consider:

- How well do you systematically gather, analyse and review safety data, both internally and from other organisations?
- How well do you learn from both ‘successes’ and ‘failures’ within your organisation and also from outside? Are those lessons widely disseminated?
- How well does your organisation act on and communicate rule-making, risk assessments, procedure changes, new technology and changing circumstances?
- How do you ensure information is communicated and shared effectively both horizontally (across different locations, departments or shifts), vertically (across hierarchical levels within the organisation) but also with customers and subcontractors?
- What are the barriers to responding to action? Cost-cutting? Lack of leadership? Lack of or contradictory incentives? Excessive secrecy? Lack of trust? Organisational silos?

Q10 How can you behave to clearly demonstrate you are an authentic safety leader who promotes trust in your organisation?

The importance of safety leadership cannot be overstated. Humility affects what you are willing to hear and learn about your organisation and its risks. Consider:

- How well do you champion safety? What do you condone by walking past?
- Do you set clear expectations for safety behaviours and objectives for safety improvement?
- Are you prepared to ‘follow’ too, when appropriate?
- Are you aware of how you come across, the messages you send and how you are perceived?
- Do you lead by example and consistently demonstrate those behaviours you expect to see in a healthy safety culture? Encourage and reward engagement in safety, demonstrate that you have an interest in the day to day operations, ‘go look see’, include safety feedback in employee briefings/communications, focus on learning and improvement.

Final word

The RAeS HFG:E believe that reflecting on these ten questions should give you some insight into how your organisation can become better at listening and learning. Acting on that insight will enhance your safety performance. They recommend revisiting the questions periodically on your journey to peak safety performance. However, it is vital to remain constantly vigilant of the reality of what is happening across your organisation.

†The HGE:E project team consisted of Stephen Bramfitt-Reid (Rolls-Royce), Colleen Butler (Health and Safety Laboratory), Andy Evans (Aerossurance), Doug Owen (The Schumacher Institute) and Tania Wilson (Virgin Atlantic Airways).

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