attitude indicator

safety newsletter

Summer 2021

VISIONAIR INTERNATIONAL

Chief Executive Safety

Message

Colleagues,

When safety and operational requirements are properly balanced and integrated, the aviation department is positioned to provide the best overall service. A Safety Management System (SMS) creates and maintains this integration and balance. Safety communication comes in several forms. Heard on an almost daily basis is the question, "Can we do it safely?" This may be asked verbally by a supervisor or another crew member. If the risk is marginal, what mitigation steps can we take to make the risk as low as reasonably practicable?

The safety reporting promotes communication within the department. It encourages discussion and information exchange .

Every employee should feel completely safe in expressing concern on safety matters without fear of retribution from supervisors. Errors in judgment, errors of commission and errors of omission should be openly admitted with the understanding that everyone can learn from the mistakes of others. The department that adheres to a "just culture" encourages open communication and takes advantage of teaching moment.

Editorial

Dear Colleague's

It is hoped that this edition of Vision Air Int'l Safety newsletter 'attitude indicator' finds you in good health and spirits. This edition of the safety newsletter comes after a lapse of several months, mainly due to Covid-19 pandemic.

Safety promotion is one of the key component of Safety Management System in the industry. Safety promotion includes training , education & communication.

In this edition , we have included article on the impact of Covid -19 pandemic on aviation workers and aviation system. Since majority of Vision Air operations is conducted during night hours, articles on fatigue management and risks associated with operation during night may be of special interest for the flying crew and operational staff.

Your suggestions and inputs shall be highly appreciated for the improvement of the next edition of attitude indicator which we plan to publish in Sep 2021.

Kausar A. Jafri (Editor)

Joan Cahill, Paul Cullen, Sohaib Anwer, and Keith Gaynor

BACKGROUND

Worker wellness and mental health is hugely important in safety critical systems such as aviation. Aviation workers need to be fit for duty and aware of all risks that compromise their health and wellbeing. Work has the potential to negatively impact on mental health particularly in the form of stress.

The COVID-19 pandemic has put increased stress on aviation workers and the aviation industry. The industry has experienced a decrease in capacity. Many workers are working on reduced salary, furloughed, or have lost their jobs. This has had a detrimental impact on their sense of purpose and financial security. Those who are still working, are working in very different environments with additional stressors.

People vary in relation to their ability to cope successfully with stress (including work-related stress). The practice of healthy behaviours strengthens a person's resistance to stress. The substitution of maladaptive coping with more adaptive coping strategies is an important component of therapeutic interventions for work-related stress. Common adaptive stress coping strategies include exercise, the practice of relaxation techniques and seeking social support and/or social participation

> One of the great differences between the amateur and the professional is that the latter has the capacity to progress.
>
> W. Somerset Maugham

Peer support programmes have been implemented by airlines for pilots. However, they are less commonplace for other aviation workers including maintenance and cabin crew.

It is likely that some aviation workers may experience significant challenges during the period of being off work. Social isolation and confinement may lead some people to develop maladaptive coping strategies. If off work, some of the occupational barriers to maladaptive coping are not there (i.e. intoxicant testing by employer). Further, the enablers of adaptive coping (i.e. support from social network, access to peer support and access to support groups within the community) are not there.

As such, the current COVID-19 pandemic poses a huge occupational health and safety risk. The Flight Safety Foundation has identified three operational scenarios to be managed during the COVID-19 crisis and beyond .

(1) being at work during the COVID-19 outbreak,
(2) being off work, and
(3) returning to work.

ABOUT SURVEY

Researchers at Trinity College Dublin(TCD), Ireland conducted an anonymous online survey, to address the impact of the COVID 19 pandemic on:

(1) job and employment,
(2) wellbeing and morale,
(3) performance and safety behaviour, and
(4) safety oversight.

The survey also investigated reporting culture, coping strategies, fitness to work assessment, and the supports provided by aviation companies to workers during the pandemic.

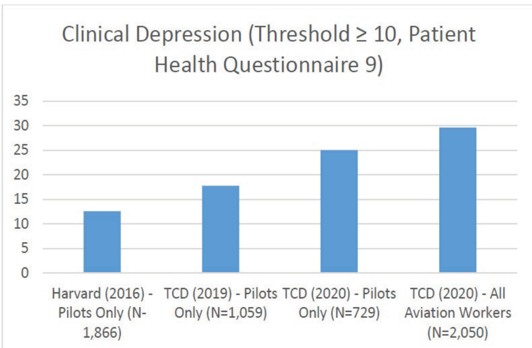
The survey was administered over three weeks in August 2020 and completed by 2,050 aviation workers. The respondent breakdown was as follows: 38% Pilots, 19% Cabin Crew, 11% Air Traffic Control, 8% Maintenance/Engineering, with the remaining 24% spanning other aviation workers.

SURVEY FINDINGS

Of those surveyed, 50.95 % have lost their jobs, with 41.41% indicating that this is permanent. Of the 50.95% who have lost jobs, 66% are currently seeking reemployment within aviation, while 88.94% intend to regain similar employment after the COVID-19 pandemic. 56.70% were obtaining financial support from government or another agency.

Survey findings indicate an increase in the prevalence of depression for pilots as compared with the findings of other similar surveys undertaken at Harvard University in 2016, and Trinity College in 2019 [see Figure 1].

Figure 1



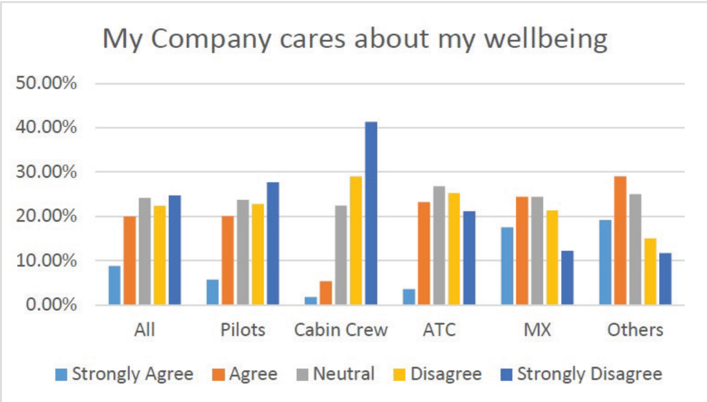
In terms of depression levels, there are higher numbers meeting the threshold for moderate depression (17.7%), moderately severe depression (7.4%), and severe depression (4.5%). Cabin Crew have higher levels of suicidal ideation, with maintenance workers experiencing levels similar to other aviation workers.

The survey also indicates that aviation workers are experiencing high levels of anxiety. Of those surveyed, 36% met the threshold for mild anxiety, 12.8% for moderate anxiety and 11.3% for severe anxiety.

Over 60% of those surveyed either strongly agree or agree that their mental health has worsened since the COVID-19 Pandemic, with Cabin Crew most negatively impacted.

Of those surveyed, Maintenance Engineers were most in agreement that their company cares about their wellbeing [see Figure 2].

Figure 2



A low number of respondents (32%) either strongly agreed or agreed that 'supporting and maintaining positive mental health for aviation 'Safety-Critical Workers' during the COVID-19 pandemic is a key priority for their organization.'

Survey findings indicate a weak response from organisations in terms of helping employees cope with the stress arising from COVID-19 and changes to their wellbeing. 75.41% of respondents indicated that their company has not provided supports. Further, the use of company supports is very low – with 24.27% indicating that they have used the supports provided by their organisation.

The survey asked respondent who might approach at their company for support. Of those surveyed, Maintenance Engineers were least aware of peer support programmes (PSP) within their organisation. Further, Maintenance Engineers appeared to have the lowest levels of trust in peer support programmes. Not one Maintenance Engineer who participated in this survey reported speaking to PSP representatives [see Figure 3].

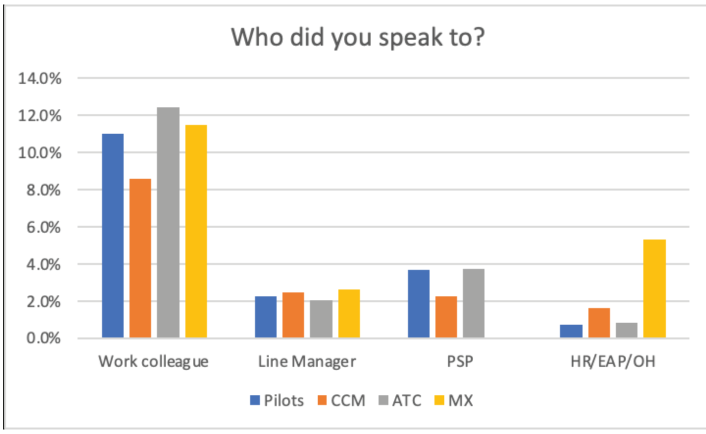


Figure 3

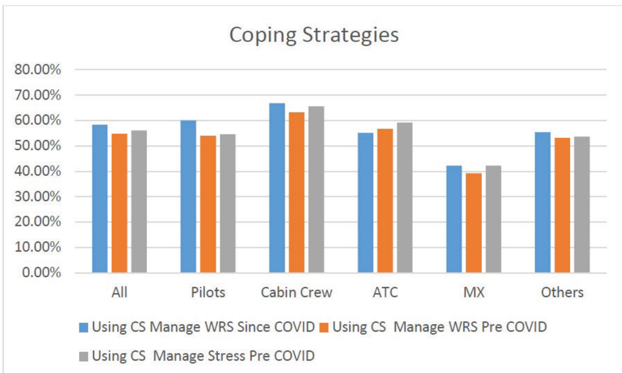
However, Maintenance Engineers showed the highest levels of willingness (nearly 30%) to disclose a mental health issue that they experienced to their employer, as compared with approximately 20% of pilots, cabin crew and ATC.

Survey results indicate a strong need for supports for aviation workers currently in work and working in 'safety critical roles' and currently in work. Over 92% either strongly agree or agree that they need support to maintain wellbeing during the COVID-19 pandemic.

"SURVEY RESULTS INDICATE A STRONG NEED FOR SUPPORTS FOR AVIATION WORKERS CURRENTLY IN WORK AND WORKING IN 'SAFETY CRITICAL ROLES' AND CURRENTLY IN WORK."

On a positive note, the survey indicates that aviation workers across different roles are using coping strategies (CS) – with over 57% using different coping strategies. Of those surveyed, Maintenance Engineers have the lowest levels of self-care practice. This is making a difference to aviation worker mental and physical health, along with improving safety. Also, the use of self-care strategies is important in terms of promoting a wellbeing culture [see Figure 4].

Figure 4



WELLBEING BEHAVIORS & 'WELLBEING WHEEL'

Following from a preventative and self-management approach, the Flight Safety Foundation have produced a guide to support wellbeing management and resilience for aviation professionals both during the COVID-19 crisis and after. The guide invites aviation professionals to consider three key wellbeing questions:

(1) how am I feeling,
(2) how am I coping, and
(3) what am I going to do/what am I doing?

Drawing upon the 'biopsychosocial' model of health and wellbeing, the guide proposes the use of specific self-management strategies. As indicated in diagram below, these include, activities, physical exercise, diet, sleep, stress management, and social relationships [see Figure 5].

Wellbeing behaviours (Flight Safety Foundation)

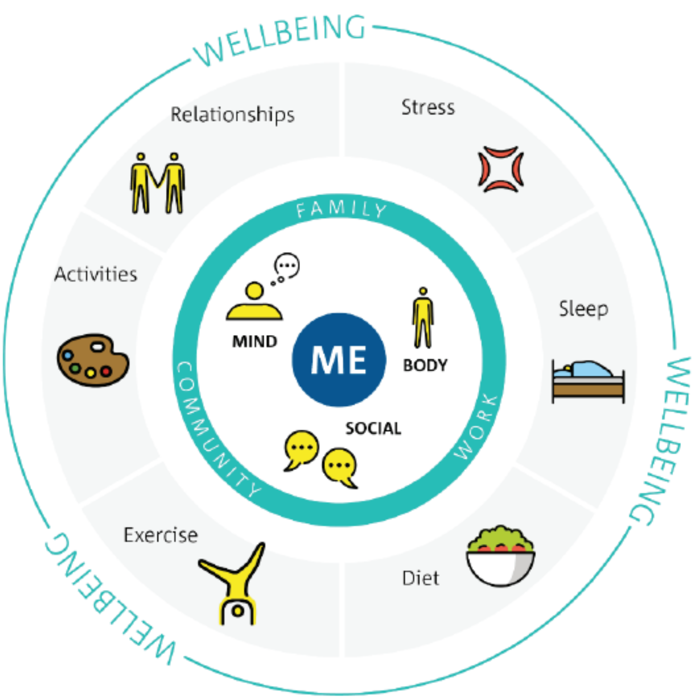


Figure 5

CONCLUSIONS

Those aviation workers who have lost their jobs and/or are experiencing mental health issues require immediate support.Organisations and workers need to manage specific sources of stress (including work related stress) and anxiety, and the specific impact of COVID-19 on aviation workers. Aviation workers across different roles are practising self-care – this should be encouraged at all levels – linking to promoting a wellbeing culture and safe behaviour. There is a need for peer support programmes for all aviation workers, and not just for pilots. Aviation organisations need to rethink their objectives and approach in terms of providing appropriate wellbeing supports for those currently in work and off work. Potentially, the existing supports provided to aviation workers are not fit for purpose. A preventative approach is required to ensure that all aviation workers are fit for duty when they return to work. There is a real need for aviation organisations to actively promote and enable a wellbeing culture – supporting healthy behaviour, promoting awareness of mental health, and enabling workers to talk about their mental health.

CEOs

should be paid according to the amount of time they could remain dead in their office with no one noticing. If a long time, it means they are concentrating on low frequency, long range decisions, which is what they are paid for.

Excerpts from the book titled 'How to Make Your Management Style more effective' by W. J. Reddin

THE SCIENTIFIC PRINCIPLES FOR FATIGUE MANAGEMENT

Exctract From ICAO Doc 9966 (Manual for the oversight of Fatigue Management Approaches)

The operational demands in aviation continue to change in response to changes in technology and commercial pressures, but human physiology remains unchanged. Both prescriptive fatigue management regulations and Fatigue Risk Management System (FRMS) represent an opportunity to use advances in scientific understanding of human physiology to better address fatigue risk in aviation settings.

"Fatigue: A physiological state of reduced mental or physical performance capability resulting from sleep loss, extended wakefulness, circadian phase, and/or workload (mental and/or physical activity) that can impair a person's alertness and ability to adequately perform safety-related operational duties."

Fatigue results in a reduced ability to carry out operational duties and can be considered an imbalance between:

- The physical and mental demands of all waking activities (not only duty demands); and
- Recovery from those demands, which (except for recovery from muscle fatigue) requires sleep.

Following this line of thinking, to reduce fatigue in operations, strategies reuired to manage the demands of waking activities and/or to improve sleep. Two areas of science are central to this and are the focus of this chapter.

1. Sleep science — particularly the effects of not getting enough sleep (on one night or across multiple nights), and how to recover from sleep loss; and
2. Circadian rhythms — daily cycles in physiology and behaviour that are driven by the circadian body clock (a pacemaker in the brain). Circadian rhythms include:

- subjective feelings of alertness and sleepiness;
- ability to perform mental and physical work; and
- ability to fall asleep and stay asleep (sleep propensity).

THE NEED FOR SLEEP

Have you ever wondered what happens from the time you fall asleep at night to when you wake up in the morning? If you have slept well, you will wake up feeling physically and mentally refreshed. Your experiences of the previous day will have been sorted, stored, and linked to your existing memories so that you wake up with a seamless sense of who you are. If you have not slept well, you know that the coming day will not be easy.

We are meant to spend about a third of our lives asleep. The optimal amount of sleep per night varies between individuals, but most adults require between 7 and 9 hours. There is a widespread belief that sleep time can be traded off to increase the amount of time available for waking activities in a busy lifestyle. Sleep science makes it very clear that sleep cannot be sacrificed without consequences. Sleep has multiple functions – the list keeps growing - but it is clear that it has vital roles in memory and learning, in maintaining alertness, performance, and mood, and in overall health and well-being.

TYPES OF SLEEP

NON-RAPID EYE MOVEMENT SLEEP (NON-REM SLEEP)

During non-rapid eye movement sleep (non-REM), brainwave activity gradually slows compared to waking brainwave activity. The body is being restored through muscle growth and repair of tissue damage. Non-REM sleep is sometimes described as "a quiet brain and quiet body". Across a normal night of sleep, most adults normally spend about three quarters of their sleep time in non-REM sleep.

RAPID EYE MOVEMENT SLEEP

During rapid eye movement sleep (REM sleep) brainwave activity looks similar to waking brainwave activity. However, in REM sleep, from time to time the eyes move around under the closed eyelids — the so-called "rapid eye movements" — and it is often accompanied by muscle twitches and irregular heart rate and breathing. Most adults normally spend about a quarter of their sleep time in REM sleep.

USE OF CAFFEINE

Caffeine can be useful to temporarily reduce sleepiness on duty because it blocks a chemical in the brain (adenosine) that increases sleepiness. It can also be used in advance of a period that is likely to be associated with higher fatigue (e.g. the early hours of the morning). Caffeine takes approximately 30 minutes to have an effect and can last for up to 5 hours, (but people differ widely in how sensitive they are to caffeine and how long the effects last). It is important to remember that caffeine does not remove the need for sleep and it should only be used as a short term strategy. For maximum benefit, caffeine should be avoided when alertness is high, such as at the beginning of a duty period, and instead used at times when sleepiness is expected to be high, e.g. towards the end of a long duty period or at the times in the circadian body clock cycle when sleepiness is greater.

IN THE DARK

By : Dale Wilson (Flight Safety Foundation)

Unique perceptual errors permeate all phases of night flight. Visual perception is a crucial component of human performance, but shortcomings in this important stage of human information processing are especially evident during night flights when flight crews rely on outside visual references.

Some of these limitations arise from physiological factors that impede a pilot's ability to see in the dark (Table 1). Most night-vision–related accidents, however, occur because pilots misperceive visual cues at night, especially on "dark nights" (those that are moonless and/or have an overcast sky). These perceptual errors manifest themselves during all phases of flight and are responsible for a significant number of fatal accidents.

Table 1 — Physiological Limitations of Night Vision

Physiological Limitation	Description
Dark adaptation	The eyes employ a dual receptor system — cones for day vision and rods for night vision. When moving from a lighted environment into darkness, the ability to see is initially impaired but improves with time until full dark adaptation is complete (about 30 minutes). Night (rod) vision is temporarily destroyed if the eyes are re-exposed to bright light, and it improves only after the dark adaptation process repeats its cycle. The U.S. Federal Aviation Administration (FAA) found "vision problems resulting from exposure to bright lights at night" contributed to 58 mishaps between 1978 and 2005.1
Visual acuity at night	The best possible visual acuity occurs in daylight when gazing directly at an object utilizing retinal cones located at the center of vision. Rods make up the bulk of the periphery but are completely absent from the center of the retina. Therefore, during pure night (rod) vision, there are two blind spots in each eye: one located where the optic nerve exits the retina and one in the center of vision. Visual acuity during pure night vision is the equivalent of 20/200 vision or less, as measured on a standard Snellen eye chart.2 The measurement means that, at a distance of 20 ft/6 m, a person can see what someone with normal vision can see at 200 ft/60 m.
Night myopia	When staring into the darkness of night — an empty visual field — the eyes do not focus on optical infinity but at their resting state of about 2 ft (0.6 m) to 6 ft (2 m) ahead. This empty-field (or night) myopia blurs objects in the distance, making them appear smaller and farther away, and less detectable.
Visual hypoxia	Supplemental oxygen is recommended at night to enhance visual acuity at altitudes above 5,000 ft above mean sea level (MSL) because the retina has the "highest oxygen demand and the lowest deprivation tolerance of any human structure."3

Perceptual problems abound, even during airport ground operations. Reduced lighting, combined with the sea-of-blue effect created by the maze of blue taxiway lights, hampers a crew's ability to safely navigate to and from the runway in the dark, increasing the probability of a runway incursion. For example, five of six fatal runway incursion accidents involving U.S. air carriers in the 1990s occurred during darkness (or at dusk) in visual meteorological conditions (VMC).

TAKEOFF AND CLIMB

During takeoff and initial climb, reduced ambient light has contributed to taxiway and wrong-runway departures in VMC. For example, a Bombardier Challenger crashed at Blue Grass Airport in Lexington, Kentucky, U.S., killing 49 of the 50 people aboard, as the crew attempted a takeoff on Runway 26 instead of Runway 22. The accident occurred in VMC about one hour before sunrise with no illumination from the moon.

Since the vestibular apparatus in the inner ear is unable to distinguish between straight-line acceleration and head-up or head-down tilt, pilots who rely solely on external visual cues after takeoff on clear dark nights are susceptible to experiencing a false nose-up sensation, which could cause them to mistakenly pitch the aircraft's nose down. This false climb (or somatogravic) illusion contributed to the crash of an Airbus A320 into the Persian Gulf, killing all 143 persons on board. The weather was VMC, but dark-night conditions prevailed over the water with no moon or external visual cues discernable.

EN ROUTE

Pilots flying under visual flight rules (VFR) at night are at least three times more likely to experience an accident involving inadvertent flight into instrument meteorological conditions (IMC) than they would be during the day. Not only is it more difficult to visually detect adverse weather in the dark, but it also is difficult to see high terrain. While flying below the San Diego Terminal Control Area (now Class B controlled airspace), and waiting for an instrument flight rules (IFR) clearance, the crew of a Hawker Siddeley HS 125 flew into terrain near Brown Field Municipal Airport, killing all aboard: It was a clear, yet moonless, night, with visibility of 10 mi (16 km). The crew of an air ambulance Learjet flew into the same unseen terrain 13 years later. While flying under VFR at night below a cloud deck and awaiting an IFR clearance, the aircraft crashed within 1.5 mi (2.4 km) of the HS 125 crash site, killing all on board. This accident, and many others like it, prompted the U.S. National Transportation Safety Board (NTSB) to issue a Safety Alert in 2008 warning pilots of the dangers of night VFR flight.

APPROACH AND LANDING

The probability of landing at the wrong airport increases when conducting a visual approach at night, even in good weather. For example, during a two-month period in 2013 and 2014, two aircraft — a 747 and a 737 —landed at wrong airports at night, prompting the NTSB to issue a safety alert that recommended modified air traffic control (ATC) procedures and cockpit software to guard against similar occurrences in the future.

IN THE DARK

The flight crews of both aircraft had conducted their respective approaches relying primarily on outside visual references.
Another concern is the likelihood of experiencing an illusion when conducting a visual approach after dark. The inability to see terrain on the approach, and the subsequent lack of optic flow (the rate at which objects in our peripheral vision flow past us as we move through space), means pilots must rely on runway shape and slope and atmospheric opacity to judge their approach angle.
Among the most common illusions is the black hole illusion. The absence of well-lighted terrain between the aircraft and the runway in dark-night conditions leads pilots to perceive that the approach angle is too high, causing them to fly too low. No single theory fully explains the cause of this illusion, but the most prominent explanation suggests that pilots attempt to maintain a constant visual approach angle, which results in a curved approach path and dangerously low approach (Figures 1 and 2).

Figure 1 — Constant Approach Angle Results From Increasing Visual Angle

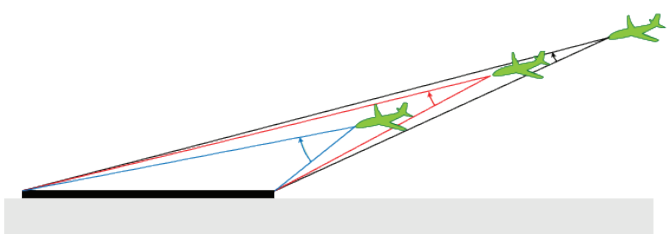
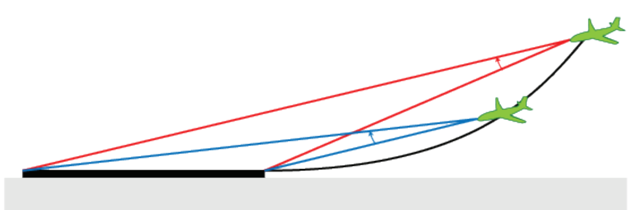
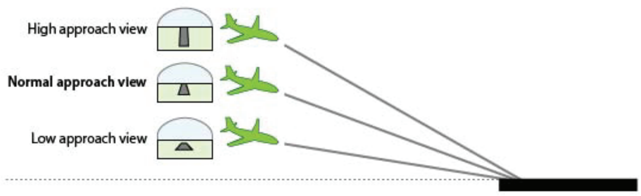


Figure 2 — Curved Approach Results From Constant Visual Angle



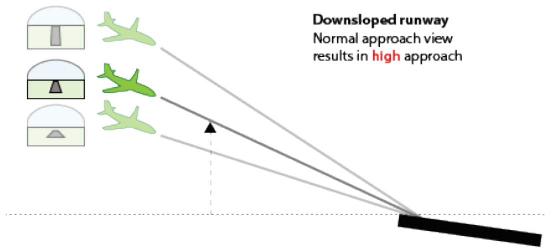
Other illusions involve the runway slope. Pilots judge the aircraft's approach angle by unconsciously comparing a runway's trapezoidal retinal image with the familiar runway shapes stored in their perceptual memory system (Figure 3).

Figure 3 — Different Runway Approach Views from the Flight Deck.



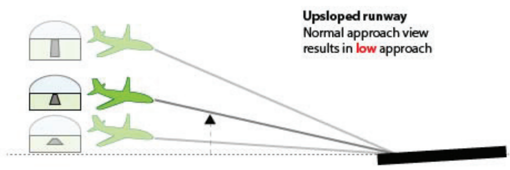
A pilot unaware of a runway's slope will instinctively adjust the approach angle to ensure that he or she sees that familiar shape. For example, on the correct approach to a downsloping runway, the low-approach image on the retina causes the pilot to perceive the approach angle as too low, resulting in a high approach with a possible long landing, runway overrun or stall above the runway (Figure 4).

Figure 4 — Effect of Downsloping Runway on Approach



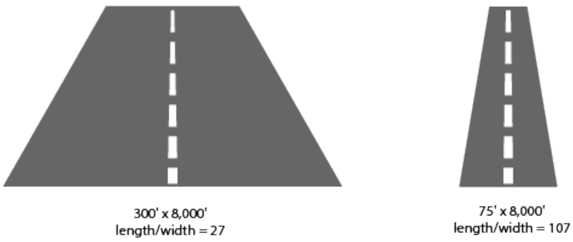
Conversely, on the proper approach to an upsloping runway, the high-approach retinal image causes the pilot to perceive the approach angle as too high, resulting in a low approach with a possible hard landing or controlled flight into terrain (CFIT) accident short of the runway (Figure 5). An upsloping runway in Halifax, Nova Scotia, Canada, led both crewmembers of a Canadian Airlines 767 "to believe the aircraft was higher than it actually was" causing them to fly too low, resulting in a premature hard landing and tail strike, the Transportation Safety Board of Canada (TSB) said.12

Figure 5 — Effect of Upsloping Runway on Approach



Illusions also can involve runway dimensions. Research conducted in the 1980s confirms that pilots erroneously perceive an aircraft's approach angle as too high when they are approaching a runway with a greater length-to-width (L/W) ratio that makes it appear longer and/or narrower than they are accustomed to. For example, a pilot who is accustomed to the runway dimensions on the left in Figure 6 is likely to experience a height illusion when approaching the runway on the right, with its higher L/W ratio. As a result, the pilot flies a lower approach.

Figure 6 — Runways With Different Length/Width Rations

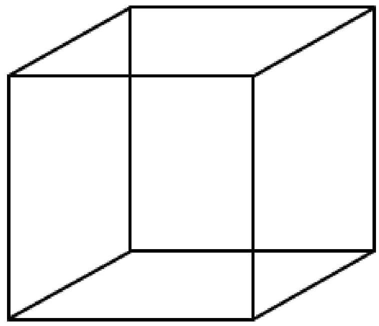


An object of known size that casts a smaller image on the retina is correctly perceived as being farther away from the viewer, not smaller in size. This relative size cue may cause a pilot to misperceive a runway's distance if it is larger or smaller than the runway they are most accustomed to. For example, the top runway in Figure 7 is half the width and length of the other but shares the same proportions (same L/W). At night, when surrounding visual cues are absent, a pilot accustomed to the bottom runway will likely construe the top one as farther away. If the brain interprets this illusion as an increase in vertical distance (altitude) the pilot will believe the approach is too high and fly a low approach; if the pilot perceives it as an increase in horizontal distance, he may delay the descent and end up too high on the approach.

Figure 7 — Different-Sized Runways with Same Length/Width Ratios

Atmospheric conditions also can influence pilots' perceptions. Since distant objects are normally less distinct than closer ones, a pilot may overestimate a runway's distance in exceptionally hazy atmospheric conditions and underestimate it in exceptionally clear conditions. Similar illusions occur if runway lights are dimmer or brighter than normal: The former creates an illusion of distance (lights appear small and dark), and the latter, an illusion of closeness (lights appear large and bright). Different responses are possible, depending on whether the illusion is perceived vertically or horizontally by the brain. However, dimmer runway lights tend to contribute to late landing flare-outs and hard landings, while brighter lights have the opposite effect.

Figure 8 — Example of Ambiguous Figure (Necker Cube)



Pilots are vulnerable to visual illusions in conditions of visual ambiguity. In such conditions, an object's image on the retina doesn't lie, but sometimes the perceptual interpretation of it does. For example, the top two-dimensional square in Figure 8 looks like it might be the front of a three-dimensional cube, but the next moment it may appear to be the back of the cube. But there is no cube: The lines are two-dimensional. The subconscious perceptual part of our brain wants to interpret it as three-dimensional, and since there isn't enough contextual information to accurately perceive its orientation, the figure keeps reversing.

COUNTERMEASURES

The following non-exhaustive list of best practice countermeasures should be implemented by flight crews to effectively compensate for the visual limitations that manifest themselves after dark.

• AIRPORT GROUND OPERATIONS

Attain and maintain dark adaptation before and during a flight at night. If possible, avoid exposure to bright lights; if unable, close one eye and allow only the other to be exposed.

• TAKEOFF AND CLIMB

Perform a compass/heading indicator check while lining up to confirm correct runway alignment.
Avoid departures into black-hole conditions and depart over well-lighted terrain during night VFR operations.
To ensure an adequate climb gradient, supplement outside visual references with flight instruments until outside references are unambiguous.

• EN ROUTE

Know the geographical position of the aircraft and its relation to higher terrain at all times using radio navigation aids and/or the own-ship moving map display common on many multifunction displays.

Fly at or above minimum safe obstruction clearance altitudes.

During night VFR operations, if possible, fly in high lighting conditions, which the U.S. Federal Aviation Administration (FAA) Aeronautical Information Manual defines as either a sky condition less than broken (5/8) cloud coverage and a moon with at least 50 percent illumination, or surface lighting that provides for the lighting of prominent obstacles, the identification of terrain features and a horizontal reference by which aircraft control can be maintained.

• APPROACH AND LANDING

Ascertain the presence of sloping runways or runways conducive to black-hole conditions before conducting an approach at night.

Use instrument landing system or other glide path instruments to assure safe obstacle clearance.

Use runway visual approach slope indicator (VASI) lighting systems.

Avoid visual approaches at night; however, if required by ATC, reference glide path instruments and/or VASI guidance to maintain a safe approach angle.

The probability of an accident increases substantially when pilots rely too much on their visual ability to accurately perceive the outside world during the hours of darkness. Using these risk-reduction strategies will go a long way to reducing that threat.

UPSET BY FALSE CUE *by Mark Lacagnina*

A system of standard calls should be developed to provide commercial flight crews with initial guidance for handling abnormal and unexpected occurrences in flight, says the Swedish Accident Investigation Authority (SHK). The SHK believes such guidance might help to prevent accidents similar to the one that befell a Bombardier CRJ200 the night of Jan. 8, 2016.

Investigators found that there was no immediate communication or coordination between the CRJ pilots when the pilot-in-command's (PIC's) primary flight display (PFD) indicated that the airplane's pitch attitude was increasing rapidly. The PIC's surprised reaction to the pitch indication led to an upset from which recovery was not accomplished. The pitch indication was found to have been erroneous and precipitated by a malfunctioning inertial reference unit (IRU).

The accident occurred in Oajevágge, Sweden, during a cargo flight carrying mail and packages from Oslo to Tromso, both in Norway. The airplane was being operated as Air Sweden Flight 294 by West Atlantic Sweden AB.

NO SIGNIFICANT WEATHER

The flight crew had reported for duty at 1810 local time and were flying the second round-trip flight between Oslo and Tromso that evening in the same airplane.

The PIC, 42, held an airline transport pilot license and had 3,365 flight hours, including 2,208 hours in type. He had received his basic flight training in Spain and had flown as a CRJ900 pilot with another operator before being employed by Air Sweden. The PIC served as the pilot flying during the accident flight.

The copilot, 33, had a commercial pilot license and 3,232 flight hours, including 1,064 hours in type. He had received his basic flight training in France and had begun his commercial flight career with Air Sweden as a BAe Jetstream 61 pilot.

Light snow was falling at Oslo, but no significant weather was forecast for the flight to Tromso. Estimated flight time was 1 hour and 43 minutes, and the planned departure time was 2300. However, the departure was delayed about 9 minutes while the crew had the airplane deiced. The airplane was a CRJ200-PF (package freighter), a short- to medium-range cargo transport.

"The takeoff, departure and climb to the cleared flight level, FL 330 [approximately 33,000 ft], were performed according to normal procedures," the report said. "The autopilot was engaged during the climb at approximately FL 180. At 2337, the aeroplane was established in level flight at FL 330. … All recorded DFDR [digital flight data recorder] parameters were stable with normal values from the point in time when the aeroplane first leveled out at the cruise altitude."

Cockpit voice recorder (CVR) data indicated that after establishing cruise flight at FL 330, the pilots engaged in some private conversations. "No language barriers were observed, which indicates that the communication between the pilots was not hampered or deteriorated for reasons of language," the report said.

DEPENDENT ON INSTRUMENTS

The CRJ was cruising at an indicated airspeed of 275 kt in dark night visual meteorological conditions. "The lack of external visual references meant that the pilots were totally dependent on their instruments which, inter alia, consisted of three independent attitude indicators," the report said.

Attitude information is provided by PFDs on the left and right sides of the instrument panel, and by a standby attitude indicator in the center of the panel. Attitude data for the PFDs is generated by an inertial navigation system comprising two IRUs.

"Each IRU consists of three ring laser gyros (RLGs), a three-axis accelerometer and the computing section," the report said. "An RLG senses angular changes around its axis by measuring frequency differences between the two counter-rotating laser beams. The accelerometers sense acceleration along the same axis. … Hence, the IRU calculates the three-dimensional trajectory and the aeroplane's angles in pitch, roll and yaw axis."

The information provided on each PFD is monitored by a comparator system, which flashes warnings on the flight displays if the information varies from prescribed limits — for example, if the pitch or roll information provided on the PFDs varies by more than 4 degrees.

The "miscompare" warnings and other information are removed from the flight displays if the airplane enters an unusual attitude — that is, if the pitch attitude shown in either PFD exceeds 30 degrees nose-up or 20 degrees nose-down, or when the displayed roll angle exceeds 65 degrees. This function is called "decluttering" and is designed to help pilots focus on remaining information deemed pertinent in recovering from the unusual attitude.

SURPRISE EFFECT

The flight path from Oslo to Tromso took the airplane into Swedish airspace controlled by Norwegian air traffic control (ATC). The crew was told to expect clearance for a circling approach to the Tromso airport.

The pilots were conducting an approach briefing at 0020 when the erroneous pitch indication first appeared on the PIC's flight display. From what had been a constant indication of about 1-degree nose-up in cruise flight, the indicated pitch attitude increased to 1.7 degrees momentarily, then to 36 degrees at a rate of 6 degrees per second. The airplane, however, remained in level flight. "The recorded altitude, speed and angle-of-attack remained unchanged," the report said.

The PIC's display briefly flashed an amber "PIT" miscompare warning, indicating that the pitch information did not compare with that shown on the copilot's PFD. Although the PIC's flight display indicated an increasing nose-up pitch attitude and a flight director command to lower the nose, the copilot's display showed the airplane in level flight and a flight director command to maintain the indicated pitch attitude.

As the indicated pitch attitude increased through 15 degrees on the left PFD (see Figure 1), an exclamation by the PIC — "What!" — was captured by the CVR. "SHK's opinion is that the pilot-in-command at this moment was exposed to a surprise effect because of the difference between what was expected and what was displayed," the report said. "As the left PFD displayed information that was not consistent with the aircraft's actual movement and external visual references were absent, the pilot-in-command [also] was subjected to a degradation of his spatial orientation."

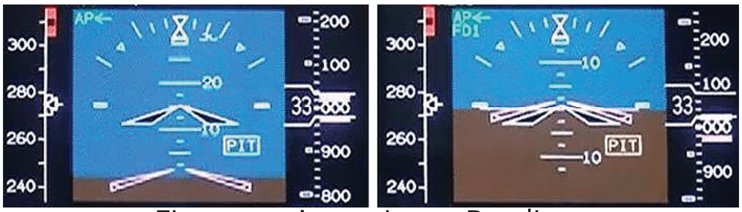


Figure 1 — Inconsistent Readings

At the beginning of the upset, the pilot's primary flight display (left) showed, erroneously, that the airplane's pitch attitude was increasing rapidly, while the copilot's display (right) indicated level flight. Note the boxed "PIT" symbols, warning that the PFD information did not compare.

The crew then received an aural warning that the autopilot had disengaged. "According to the aeroplane's manufacturer, the autopilot was most likely automatically disconnected due to differences in the pitch servo commands [generated by the IRUs]," the report said. "The aural warning remained active for the next 18 seconds."

REACTING BY INSTINCT

Neither pilot commented on what was happening. "The lack of a prescribed procedure and standard callouts for automatic autopilot disconnection might explain why this was not commented upon or acknowledged by the crew," the report said. "Furthermore, it was not made clear verbally that any of the pilots had assumed manual control of the aeroplane."

Reacting to the erroneous indications on his PFD, the PIC pushed his control column forward and applied nose-down trim to reduce the airplane's pitch attitude. Recorded flight data showed that "both elevators moved towards nose-down and [that] nose-down stabilizer trim was gradually activated from the left control wheel trim switch," the report said. "The aeroplane started to descend, the angle-of-attack and G-loads became negative. Both pilots exclaimed strong expressions."

The SHK determined that the PIC's reaction was instinctive and consistent with his training. "Pilots have learned since basic instrument training to rely on their instruments," the report said. "The fact that the pitch angle displayed on the left PFD was high and increasing rapidly in combination with the [flight director] display requesting pitch-down inputs probably contributed to the pilot's instinctive reaction to act according to the displayed unusual attitude."

When the pitch attitude shown on the PIC's flight display increased through 30 degrees, the PFD went into the declutter mode. Among the secondary information removed from the PFD was the pitch miscompare warning. The PFD also generated an additional, and prominent, steering command — large red chevrons prompting the PIC to decrease the airplane's pitch attitude (see Figure 2).

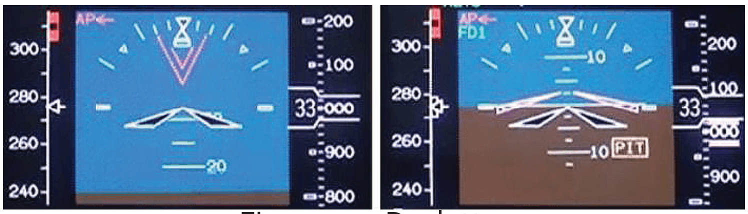


Figure 2 — Declutter

When the indicated pitch attitude exceeded 30 degrees, the pilot's PFD "decluttered," removing information such as the miscompare warning, and presented red chevrons prompting a decrease in pitch attitude. The miscompare warning later was removed from the copilot's display, as well, when the bank angle exceeded 40 degrees.

COGNITIVE TUNNEL VISION

The substantial negative G-load that resulted from the PIC's nose-down pitch inputs and the large number of audio and visual warnings that were being presented to the pilots likely caused them to experience "cognitive tunnel vision," the report said. They likely focused solely on their individual flight displays and disregarded, or were unable to assimilate, other information, such as that provided by the standby flight instruments.

"By this time, the pilots probably had different perceptions of the situation because of differences in the display on the respective attitude indicator," the report said. "A basic prerequisite for the crew to jointly cope with the situation was sharing the same perception, or mental model, of the situation. [Communication is necessary] to achieve a common perception, or mental model."

The SHK concluded that if the pitch miscompare warning had been retained after the PIC's flight display went into declutter mode, the pilots eventually might have detected the erroneous indications on the PIC's display. "It is … difficult to understand why indications related to instrument errors are removed," the report said. "The decluttering of the caution indications on the PFD displays during unusual attitudes is a weakness in the system design."

The CVR recorded sounds similar to loose objects striking the cockpit roof due to the negative G-loads being imposed on the airplane, as well as an aural warning of low engine oil caused by loads imposed on the engines and several exclamations by the pilots as the upset progressed.

STEEP BANK

Nine seconds after the upset began, the airplane started to bank left. This likely resulted when the copilot grabbed the control yoke for support while being pushed upward by the negative G-load, the report said. A few seconds later, the enhanced ground-proximity warning system (EGPWS) sounded a warning that the bank angle had reached at least 40 degrees.

The declutter mode by now had activated in the copilot's PFD, which showed indications of a steep left bank and a 20-degree nose-down pitch attitude, as well as red chevrons providing a nose-up steering command. The copilot likely was reacting to these indication when he shouted "come up" and then "turn right." The PIC said, "Come on, help me, help me, help me." The report noted that this was the first time since the start of the event that the pilots attempted to communicate with each other.

The PIC's display was still showing a steep nose-up pitch attitude and a nose-down steering command. "The situation at this time meant that the crew were presented with two contradictory attitude indicators with red chevrons pointed in opposite directions," the report said. Spatially disoriented and focusing solely on their PFDs, neither pilot made any verbal reference to the standby attitude indicator.

MAYDAY, MAYDAY, MAYDAY

An aural warning (a "clacker") sounded when the speed of 0.85 Mach. "The pilot-in-command asked for help again, which was answered by the copilot by saying, 'Yes, I am trying,'" the report said.

The pilots still had not realized that their PFDs were providing conflicting information. "The dialogue between the pilots consisted mainly of different perceptions regarding turn directions," the report said. "The efforts to regain control were not based on rational decisions or communication, but probably [were] the result of trained flight control inputs guided by the erroneous information."

Airspeed had reached 0.91 Mach when the copilot radioed, "Mayday, mayday, mayday, Air Sweden two niner four." Shortly after ATC acknowledged the call, the copilot said, "We [will] call you back." The crew received, but did not acknowledge two more ATC radio transmissions as the upset continued.

The report said that recorded flight data became unreliable for analysis about 24 seconds into the upset. Although CVR data indicated that the crew continued their efforts to recover from the upset, the report said that the possibility of regaining control of the airplane by this time was limited.

The CRJ was in an inverted attitude when it struck terrain in a valley at 2040. The impact occurred 80 seconds after the airplane began the descent from FL 330. The pilots were killed, and the airplane was destroyed. There was no indication that an in-flight breakup had occurred.

UNEXPLAINED MALFUNCTION

The SHK concluded that the erroneous attitude indications on the PIC's flight display had been caused by an internal malfunction of the no. 1 IRU. However, the specific cause of the IRU malfunction was not determined. The report said that there was no record of a similar malfunction and that tests by the manufacturer of the system components and software were inconclusive.

The report noted that although a miscompare warning was presented briefly on both PFDs, there was no specific indication to the crew that the no. 1 IRU had failed.

Investigators found no information in the manuals available to the crew about the removal of miscompare warnings when flight displays are decluttered. Moreover, the investigation revealed that the miscompare warnings presented to the crew during the upset were different from what they had seen during training. "The pitch and roll comparator indications of the PFDs were removed when the attitude indicators displayed unusual attitudes [during the upset]," the report said. "In the simulator in which the crew had trained, the corresponding indications were not removed."

The SHK was unable to determine conclusively if fatigue might have been a factor in the accident. Although the investigation revealed no specific findings that fatigue might have impaired the crew's performance, the report said that the event began "at a time when performance deterioration can occur due to fatigue" and that unexpected events such as the abnormal pitch indication "increase the demands on cognitive ability."

"The investigation has found deficiencies in the pilots' communication and difficulties in handling the situation," the report said. "This type of difficulty of cognitive character can be seen during fatigue. The pilots' duty hours did not exceed the flight time limitations; however, there is no information available about the crew's actual sleep time during the days preceding the accident."

COMMUNICATIVELY ISOLATED

The report said that the pilots were "communicatively isolated" from each other at the beginning of the upset. For the first 12 seconds, the CVR recorded only expressions of surprise.

Although immediate action items and specific callouts typically are prescribed for emergency procedures and required to be memorized by pilots, few manufacturers and aircraft operators provide similar guidance for abnormal and unusual situations. Because the CRJ pilots did not have such guidance to respond to the abnormal pitch attitude shown on the no. 1 PFD, "the situation evolved into problem-solving and improvisation," the report said.

Based on these findings, the SHK concluded that the accident was caused by "insufficient operational prerequisites for the management of a failure in redundant systems" and that a contributing factor was "the absence of an effective system for communication in abnormal and emergency situations."

"SHK considers that clear and distinct communication between crewmembers is essential to maintain situation awareness and thereby optimize flight safety," the report said. "The authorities and organizations publishing regulations in the matter should therefore ensure that a general system of initial standard calls is introduced in commercial aviation for clear, precise and bidirectional communication between crewmembers in abnormal and emergency, as well as unusual and unexpected, situations."

The SHK also concluded that among the factors contributing to the accident was the absence of a specific warning to the crew about the IRU malfunction. Another factor was the negative G-loads experienced during the upset, which "probably affected the pilots' ability to manage the situation in a rational manner," the report said.

Based on the findings of the investigation, the SHK recommended to the International Civil Aviation Organization and several regional and national aviation authorities that they "ensure that a general system of initial standard calls for the handling of abnormal and emergency procedures and also for unusual and unexpected situations [should be] implemented throughout the commercial air transport industry."

The SHK also called on aviation authorities to "ensure that the design criteria of PFD units are improved in such a way that pertinent cautions are not removed during unusual attitude or declutter modes."

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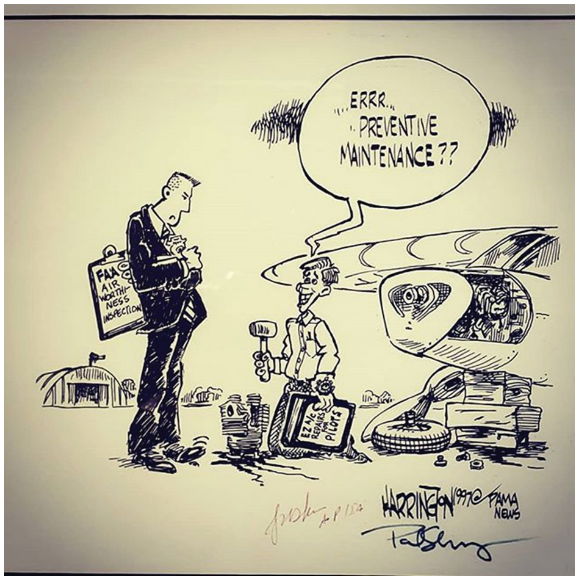

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