CAA Occurrence 20/6775

In-flight loss of situational awareness leading to spatial disorientation

ZK-HGW, Kawasaki BK117 B-2

Gowanbridge, 17 December 2020

1 - Purpose

This report outlines the factors contributing to a spatial disorientation incident, with the purpose of minimising or reducing the risk of a similar occurrence arising in the future.

With spatial disorientation events often having fatal consequences, this incident provides invaluable insight into the onset and identification of loss of situational awareness, and recovery from spatial disorientation. As such, this report has been prepared and released with the operator's knowledge, in the hope it will benefit the wider aviation industry.

Organisational aspects of this incident have been identified and are being addressed by the operator, and therefore not covered in this report.

This report includes causal factors leading to the occurrence, with specific focus on human factors elements related to loss of situational awareness and spatial disorientation.

2 – What happened

At approximately 2046 hours New Zealand daylight time (NZDT[1]) on 17 December 2020, a BK117 B-2 helicopter, departed Nelson Airport (NZNS). The crew had been tasked to transfer a patient from Reefton Medical Centre to Nelson Hospital (NZNH). The crew on board comprised of a pilot, crewman, and intensive care paramedic (ICP).

The outbound portion of the flight was to be conducted under day visual flight rules.

Due to cloud in the Reefton area, the flight was diverted to Murchison Hospital (NZUR), where the patient was transported by road, to be uplifted to NZNH. The return portion of the flight was to be conducted at night under night visual flight rules, aided by night vision goggles (NVGs[2]) as part of a night vision imaging system (NVIS[3]).

The crewman decided to sit in the front left-hand seat, after discussions with the ICP and pilot. Prior to takeoff, both the pilot and the crewman donned their NVGs and observed the local conditions as appropriate.

On departing NZUR, the pilot followed State Highway 6 (SH6) to the north. The pilot climbed the aircraft to approximately 1000 feet above ground level (AGL) with a groundspeed of 90-100 knots.

The crew discussed larger-than-normal halos emanating from vehicle headlights travelling towards them on SH6. The pilot also commented on a band of light reflecting on his side of the windscreen. All three crew members engaged in trying to identify the source of this band of light.

The pilot turned the aircraft to the right, away from SH6, and crossed a small ridge towards Kawatiri Junction, and re-converged with SH6. On crossing the ridge, the RADALT[4] activated. The crewman asked the pilot what height the RADALT was bugged at, to which the pilot stated that he thought

[1] All times and dates stated as NZDT.

[2] Night vision goggles (NVGs) are a head-mounted, lightweight, and self-contained binocular appliance that amplifies ambient light. NVGs are worn by crew members and are used to enhance the crew member's ability to maintain visual reference to the surface, at night. NVGs are one element of an NVIS.

[3] A Night Vision Imaging System (NVIS) is the integration of all the elements necessary to successfully and safely operate an aircraft with NVGs. It requires the integration and compatibility of night vision goggles and an NVIS-certified aircraft.

[4] The RADALT gives you a height above the ground directly below the helicopter.

"we are ok". The RADALT warning light was not deactivated or a new decision height selected. The crewman noted this was not a normal response from the pilot.

For approximately the next two minutes the crew continued to try identifying the source of the light band, including dimming the rear cabin lights and the instrument panel lighting.

The pilot momentarily flicked the night scanner on to assess the conditions. But this degraded the pilot's NVG picture and he turned the night scanner off.

The pilot's attention was now divided between identifying the light source, improving the quality of his visual picture, and navigating into a narrowing valley towards Kawatiri Junction along SH6.

During this time, the pilot slowed the aircraft and initiated a slight descent to approximately 500 feet AGL. The crewman noted the speed reduction and mentioned it to the pilot who replied, "Just taking it quietly to have a look". At this time the pilot stated he had good definition below and, although degraded, his forward vision was okay.

The pilot and crewman then noted the visual picture seemed to "darken off" and headlights from oncoming vehicles travelling along SH6 further degraded their forward visual picture. As a result, the pilot looked out the right side of the aircraft, to focus on the trees on the south side of the valley. The crewman, however, stated he still had," good clear visibility of the surrounding terrain and ground features."

The crewman observed a further reduction in airspeed and altitude. When raising this observation with the pilot, the crewman noticed a change in the pilot's demeanour with the pilot becoming quieter and uncertain in his responses. This led the crewman to initiate a discussion with the pilot about available options, during which time the pilot initiated a left turn.

During the turn, the crew encountered headlights from a vehicle, further degrading the pilot's visual picture. At this point, the pilot became spatially disorientated, with positive control of the aircraft being lost for approximately 60 seconds.

During this time, the crewman called for the pilot to initiate an immediate climb, along with other positive voice commands, to counteract the aircraft's rearwards and sideways movements. Commands continued until the pilot regained positive control of the aircraft.

A short time later, the pilot landed the aircraft without further incident at a nearby landing site.

2.1 - Personnel information

2.1.1 – Pilot

The pilot had accumulated over 9,100 hours (hrs) flight experience, with 126hrs of night experience. The pilot completed a BK117 type rating on 07 December 2019, accumulating a total of 180hrs in the BK117, with 150hrs as pilot-in-command (PIC), 32.8hrs PIC at night, all of which were NVIS time.

The pilot's NVIS experience started in 2006. He accumulated 75hrs of NVIS between 2006 and 2012, conducting similar operations in a different aircraft type. The pilot did not conduct any NVIS operations between 2012 and his revalidation in 2019. Since 2019, up to the time of the incident, the pilot completed 32.8hrs NVIS.

The pilot had conducted approximately 25 day-flights and three NVIS flights in the incident aircraft. The three NVIS flights equated to 3.4hrs, with the most recent being almost nine months prior to the incident flight.

The pilot had conducted several instrument proficiency demonstrations, with the most recent on 08 December 2020.

At the time of the incident, the pilot was appropriately qualified to conduct the flight.

The pilot has been a base pilot at the Nelson base since December 2019.

2.1.2 - Crewman

The crewman had been employed with the operator since 2014, and had logged approximately 400hrs of NVIS time as a crewman, with 34.9hrs logged, in the previous 12 months.

During his career, the crewman had gained extensive knowledge of the local geographical area, as well as an interest in, and a basic understanding of, the operational aspects of the aircraft.

2.2 - Aircraft information

The incident aircraft used by the base was a stand-in aircraft. This aircraft had been used as a stand-in aircraft previously, with personnel being reasonably familiar with it.

Several differences were noted by the operator, including the cockpit layout that was considered "quite different" to the usual base aircraft, as well as more cabin lighting emanating from the rear. The aircraft also had a slight distortion of the windscreen. However, this distortion was determined not to be a contributing factor to the incident.

The crew was aware of an intermittent N1 gauge fluctuation on a previous flight, causing the master caution to illuminate with an associated aural warning. The N1 gauge fluctuated during the outbound flight from NZNS to NZUR, although not during the incident flight.

2.3 - Environmental information

At the start of the duty period, an evening briefing was conducted. This briefing included discussing the relevant forecast and actual weather conditions, and the phase of the moon. No adverse weather was forecast for the Nelson-Murchison areas. However, it was noted there was negligible useful lunar illumination.

Although larger-than-normal halos were identified coming from vehicle headlights, they were attributed to an increase in atmospheric moisture levels, and deemed not to be of concern.

2.4 - Additional information

The CAA provides guidance material on situational awareness on its website.

As stated in this material, there are several factors that can impact a pilot's situational awareness, including workload, distraction, overload, and incomplete, inaccurate or poorly communicated information.

The guidance material also outlines several indicators that may suggest situational awareness has degraded. Under the section *How to detect loss of situational awareness* it states:

It is important to look for indicators that your situational awareness has degraded. The following issues may suggest that you do not have situational awareness.

Confusion: you are uncertain or uneasy about a situation or information.

Poor communication: you are giving or receiving vague or incomplete information/statements.

Fixation: you are focused on one task or element to the exclusion of everything else.

Distraction: you are frequently switching attention, not focused on the primary task.

Non-compliance: you are not following standard operating procedures or regulatory requirements.

Expected checkpoints not met: things aren't going to plan; time, progress, workload.

Ambiguous or contradictory information: you can't resolve conflicts, information from two sources does not agree or make sense.

The Australian Transport Safety Bureau (ATSB) defines the three basic types of spatial disorientation, as follows:

Type 1. Unrecognised spatial disorientation. When a pilot is unaware of any disorientation or loss of situational awareness. The pilot, unaware of the problem, continues to fly the aircraft as normal. This is particularly dangerous, as the pilot will not take any appropriate corrective action, since they do not perceive that there is in fact a problem. The fully functioning aircraft is then flown into the ground, with often fatal results.

Type 2. Recognised spatial disorientation. This is the most common form of disorientation. It occurs when a pilot detects a mental disagreement between his sensory information and his instruments. If he takes timely action, he will successfully resolve the issue before it deteriorates further.

Type 3. Incapacitating spatial disorientation. This is the most extreme type of disorientation stress. A pilot can be fully aware that something is wrong, but he is mentally and physically overwhelmed and unable to take the correct action to recover from the situation.

3 – Why it happened

It's evident the momentary loss of control of the aircraft was most likely due to the pilot experiencing spatial disorientation.

The majority of raw orientation information is gained through the visual system. In conditions where visual cues are poor or absent, such as at night, up to 80 percent of the normal orientation information is missing. In these situations, the likelihood of a disorientation event increases.

This NVIS operation was being conducted on a night with negligible useful ambient light, requiring the NVGs to operate near their highest level of gain, providing less definition.

Although the pilot had been a base pilot in Nelson since 2019, he was relatively unfamiliar with the area in which the incident occurred. Flying in an unfamiliar area can place attentional mental demand on the pilot, which can be exacerbated by challenging environmental conditions.

The aircraft the pilot was flying was a stand-in aircraft in which he had limited overall experience, and hadn't flown at night in almost nine months. It also had a different cockpit layout to the usual base aircraft.

Due to the pilot needing to focus more intently to get a good visual picture through the NVGs and the differing cockpit layout potentially impacting his ability to easily conduct an effective instrument scan, the pilot's mental workload is considered to have been higher than usual.

This high mental workload leaves very little residual mental capacity for other tasks, or to respond to any changes in the environment.

People have limited ability to divide attention amongst tasks, and generally have to switch attention back and forth between tasks. This leaves us vulnerable to losing track of the status of one task when our attention is drawn away from the task at hand, or while engaged in another task.

Early on in the flight, the pilot had become distracted by a light band reflecting on his side of the windscreen. While preoccupied with trying to identify the source of the light band, his attention had been drawn away from his primary tasks of operating the aircraft and maintaining an effective scan.

As stated in the CAA situational awareness guidance material, incomplete information, workload, and distraction can singularly, or in combination, impact a pilot's ability to maintain situational awareness. The limited information provided by the poor visual cues available, the higher-than-usual workload, and distraction caused by the light band during the flight most likely contributed to the degradation of the pilot's situational awareness.

The CAA situational awareness guidance material also explains that it is important to look for indicators that would suggest situational awareness is being degraded. There are a number of indicators to aid in identifying the onset of situational awareness degradation, such as poor communication, fixation, distraction, and confusion.

While the crew were attempting to identify the source of the light band, the RADALT activated while the aircraft was crossing a ridge. The crewman asked the pilot what height the RADALT was bugged at, noting that the pilot did not state a height, as expected. This, coupled with the unusual response "we are ok" from the pilot, is potentially the first indication of situational awareness degradation.

Another potential indicator was the ambiguous response received from the pilot, "Just taking it quietly to have a look", when the crewman mentioned the speed reduction, after entering the narrowing valley, where visual conditions degraded due to lack of ambient light.

The pilot and crewman then noted the visual picture seemed to "darken off" and was further degraded by the headlights from oncoming vehicles. The crewman stated he still had "good clear visibility", but he noticed the pilot had diverted his view/attention to the 1 or 2 o'clock position outside the aircraft. Simultaneously, the crewman observed a further reduction in airspeed and altitude.

When raising this observation with the pilot, the crewman noticed a change in the pilot's demeanour, becoming quieter and uncertain in his responses, and he appeared distracted.

Believing the pilot may be experiencing cognitive overload, the crewman initiated a discussion around available options.

It's likely, based on the indicators identified, that the pilot had lost situational awareness at this point.

The CAA situational awareness guidance material provides advice on how to recover situational awareness. This is, however, related to self-identification and recovery in the early onset stages of loss of situational awareness.

Crew resource management intends to improve safety and team dynamics by training crew in non-technical skills (leadership, communication, decision-making etc). The crewman recognised early on, that the pilot was not responding in the way he normally would. The crewman would not have been able to recognise the pilot's behavioural changes, had they not worked together previously and built a working relationship and familiarity with each other's communication styles and 'norms'. It's also likely the decision to sit in the front allowed the crewman to recognise the loss of situational awareness and help in the recovery.

During the time the pilot was experiencing degradation of his situational awareness leading to spatial disorientation, the crewman was in a more favourable position, having a significantly lower workload and having maintained his visual picture. Faced with an extremely stressful and unique situation, the crewman was able to focus his attention, and draw on his aviation experience, to clearly communicate basic commands to the pilot to aid the recovery of the aircraft back to controlled flight.

4 – Conclusions

The momentary loss of control of the aircraft was most likely due to the pilot experiencing spatial disorientation.

The most likely contributing factor to the pilot experiencing spatial disorientation, is because he had lost situational awareness.

The pilot likely encountered a degradation in situational awareness due to the limited information provided by the poor visual cues available, the higher-than-usual mental workload, and distraction.

The crewman was able to identify the indicators of degradation in the pilot's situational awareness, due to his working relationship with the pilot, and familiarity with the pilot's communication norms.

The crewman was able to assist the pilot's recovery from spatial disorientation, based on having maintained his own visual picture and his own aviation experience, enabling him to clearly communicate basic commands to the pilot.

The pilot was able to regain control of the aircraft and land without further incident.

The pilot and crewman were appropriately qualified to conduct the flight.

5 – Safety messages and recommendations

The ATSB research shows that experience does not protect a pilot from spatial disorientation. It's not the junior pilot who gets disorientated – some studies show the more at-risk pilot is the highly proficient one. Disorientation can affect any pilot, any time, anywhere, in any aircraft, on any flight, depending on the prevailing circumstances. A pilot's experience of disorientation does not preclude it from ever happening again to them. It does, however, allow the disorientation phenomenon to be recognised more readily in the future. Awareness and preparedness are key elements in preventing a spatial disorientation accident.

The ATSB research further indicates there are many steps that can be taken by pilots to minimise their risk of experiencing spatial disorientation on a given flight, many of which involve preflight planning and adequate preparation. Being aware of the risk of spatial disorientation is one of the key elements in preventing a spatial disorientation accident. Increasing awareness of spatial disorientation illusions and planning for their possible appearance at different stages of flight in the preflight planning process are essential.

It's evident from this incident that a loss of situational awareness can result in spatial disorientation. As highlighted in the CAA's situational awareness guidance, to recover situational awareness, it's important to recognise that your situational awareness has degraded. This event highlights it's not always easy to identify in yourself when your situational awareness has been compromised. It's therefore important to be aware of the indicators of loss of situational awareness.

Consideration should be given to single pilot operations, where a crewman with operational knowledge and an understanding of human factors such as situational awareness, may provide an additional opportunity to reduce the risk of the loss of situational awareness going undetected.

There are very few loss of situational awareness or spatial disorientation incidents reported to the CAA. This incident highlights valuable information on how the loss of situational awareness can lead to spatial disorientation, and what the indicators are that can be detected and ultimately recovered from. The CAA encourages participants to report any loss of situational awareness, or spatial disorientation events, to enable accurate guidance material to be provided.

There is no formal qualification in New Zealand for the role of a helicopter crewman specifically involved in helicopter emergency services (police, medical, and search and rescue). The CAA is currently giving due consideration to conducting research on crewman standards available in other states and assessing the applicability of those standards in New Zealand.

About the CAA

New Zealand's legislative mandate to investigate an accident or incident are prescribed in the Transport Accident Investigation Commission Act 1990 (the TAIC Act) and Civil Aviation Act 1990 (the CA Act).

Following notification of an accident or incident, TAIC may conduct an investigation. CAA may also investigate subject to Section 72B(2)(d) of the CA Act which prescribes the following:

> **72B Functions of Authority**
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> (2) The Authority has the following functions:
>
> (d) To investigate and review civil aviation accidents and incidents in its capacity as the responsible safety and security authority, subject to the limitations set out in section 14(3) of the Transport Accident Investigation Commission Act 1990

The purpose of a CAA safety investigation is to determine the circumstances and identify contributory factors of an accident or incident with the purpose of minimising or reducing the risk to an acceptable level of a similar occurrence arising in the future. The safety investigation does not seek to ascribe responsibility to any person but to establish the contributory factors of the accident or incident based on the balance of probability.

A CAA safety investigation seeks to provide the Director of Civil Aviation with the information required to assess which, if any, risk-based regulatory intervention tools may be required to attain CAA safety objectives.