CAA OCCURRENCE 19/8168

CESSNA 172

ZK-SBK

LOSS OF CONTROL - SOLO NIGHT FLIGHT TRAINING

LAKE ELLESMERE, CANTERBURY

21 NOVEMBER 2019

Photo courtesy of Mr Bill Mallinson©

Foreword

New Zealand's legislative mandate to investigate an accident or incident is 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 inquiry. The Civil Aviation Authority (CAA) may also investigate subject to Section 72B(2)(d) of the CA Act which prescribes the following:

72B Functions of Authority

(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 Ac t 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.

Contents

Glossary of abbreviations

AOB	Angle of bank
ATSB	Australian Transport Safety Bureau
CAA	Civil Aviation Authority
CPL	Commercial Pilot Licence
GAP	Good Aviation Practice booklet
NZCH	Christchurch aerodrome
SD	Spatial disorientation
VFR	Visual flight rules

Data summary

Aircraft type, serial number and registration:	Cessna 172P, s/n:1725566, ZK-SBK
Number and type of engines:	One, Lycoming O-320-D2J
Year of manufacture:	1982
Date and time of accident:	21 November 2019, 2216 hours[1] (approximately)
Location:	Lake Ellesmere, Canterbury Latitude[2]: S 43° 46’ 09.42” Longitude: E 172° 32' 24.08”
Type of flight:	Solo training
Persons on board:	Crew: 1
Injuries:	Crew: 1 fatal
Nature of damage:	Aircraft destroyed
Pilot-in-command’s licence:	Private pilot licence (aeroplane)
	206 hours 85 on type
Investigator in Charge:	Mr PG Stevenson-Wright

[1] All times in this report are NZDT (UTC + 13 hours)

[2] WGS-84 co-ordinates

Executive summary

The Civil Aviation Authority (CAA) was notified of a fatal accident at 2300 on Thursday 29 November 2019 involving ZK-SBK. The Transport Accident Investigation Commission was notified and chose not to open an inquiry. A CAA safety investigation was commenced the following day.

The student was conducting a solo night flight under visual flight rules (VFR). The aircraft had been operating in the Lake Ellesmere area for approximately 25 minutes prior to the accident. The investigation determined that the aircraft had been in a high-speed spiral descent prior to its collision with terrain.

The student completed a commercial pilot licence (CPL) cross-country flight test that morning before returning that evening to carry out the night flight training.

Fatigue, combined with visual and sensory illusions and low night flying time experience, were likely contributing factors to this accident.

The training organisation has made numerous procedural changes since the accident. The CAA will publish a *Vector* article describing the threats of pilot fatigue and visual illusions with specific reference to night flying.

1. Factual information

1.1 History of the flight

1.1.1 The pilot (now referred to as the student) was booked for his CPL cross-country flight test the morning of the fatal flight. He arrived at the training organisation at 0725 and after successfully completing the flight test he left the premises at 1333.

1.1.2 The student returned at 1636 in preparation for a solo night flying booking in the aerodrome circuit, but was unable to obtain a solo circuit training slot.

1.1.3 As an alternative, the duty instructor authorised him to operate in the training organisation's 'Selwyn training area' which encompasses Lake Ellesmere.

1.1.4 The student declared himself 'fit to fly' that evening by completing the training organisation's mandatory 'solo pre-signout checklist' declaration.

1.1.5 The aircraft departed Christchurch aerodrome (NZCH) to the south at 2142 to operate over Lake Ellesmere, where it conducted a series of left and right turns (refer to Figure 1). During the final turn the aircraft departed controlled flight and impacted a sand spit on Lake Ellesmere.

1.1.6 The accident occurred at 2216 at 11 feet above mean sea level. Latitude S 43° 46’ 9.42”, longitude E 172° 32' 24.08”.

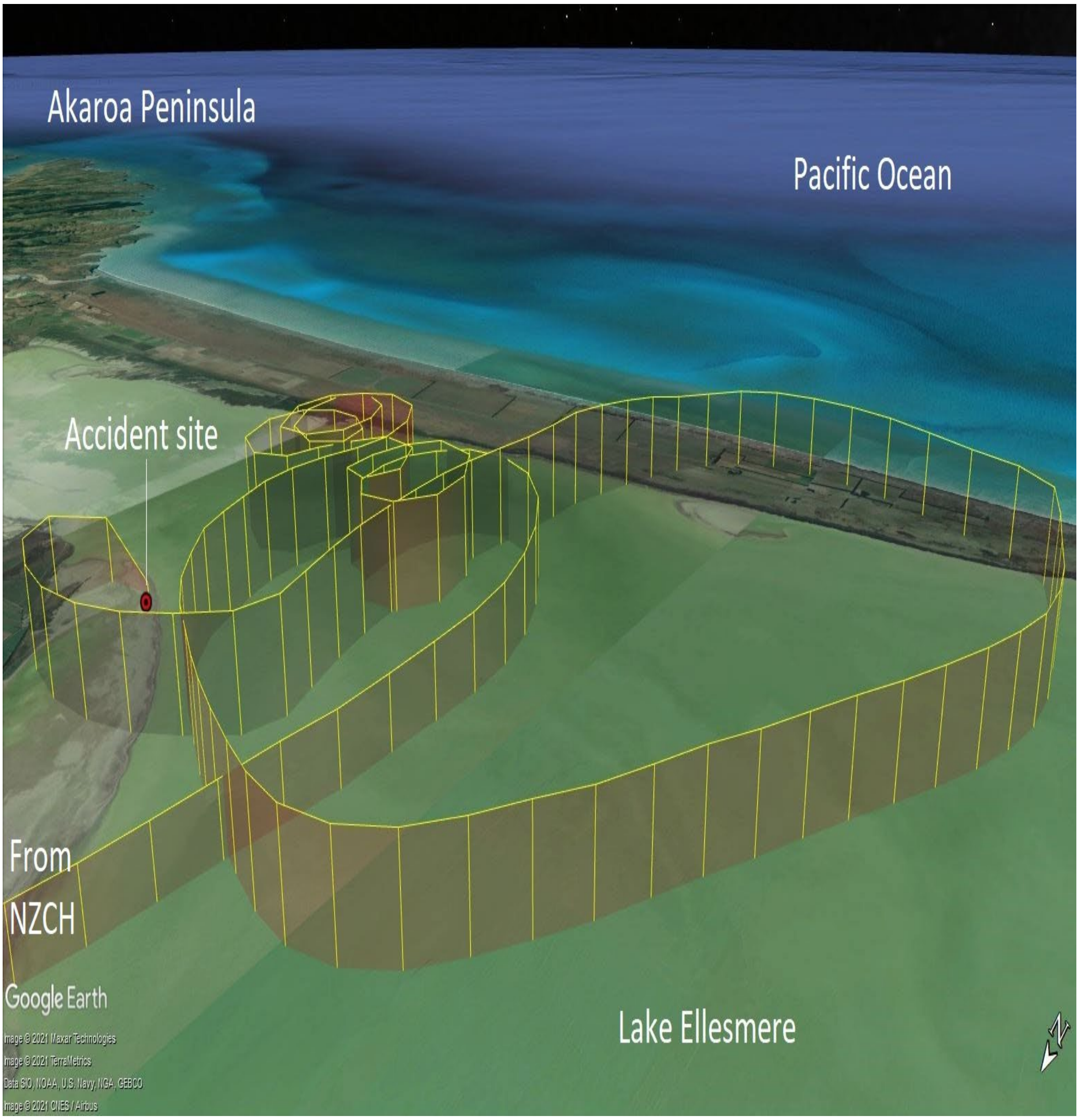

Figure 1. ZK-SBK track while operating over Lake Ellesmere (Google Earth™).

1.2 Injuries to persons

Injuries	*Crew*	*Passengers*
Fatal	1	0

Table 1: Injuries to persons

1.3 Damage to aircraft

1.3.1 The aircraft was destroyed.

1.4 Other damage

1.4.1 Nil.

1.5 Personnel information

1.5.1 The 23-year-old student held a valid New Zealand private pilot licence (aeroplane) and a current Class 2 medical certificate.

1.5.2 The student was conducting five hours of night flying as part of his private pilot licence requirements. His first dual night flight was 1.30 hours duration on 18 September 2019. He then logged 0.8 hours dual and 0.5 hours solo two nights before the accident. Both flights were in aircraft equipped with a glass cockpit[3] instrument panel.

1.5.3 The student had logged 5.0 hours of simulated instrument time in May 2019, as part of the private pilot licence syllabus requirements.

1.5.4 His total flying experience, including the accident flight, was 206.6 hours, with 84.4 hours on the Cessna 172 series aircraft recorded in his pilot logbook.

[3] Glass cockpit refers to the design where information from many different flight and engine instruments are displayed in one or more large multi-function display screens.

1.6 Aircraft information

1.6.1 Cessna 172P ZK-SBK had accrued 16,698 hours total flight time up to the accident. The most recent maintenance check was a 50-hour inspection, carried out on 29 October 2019, after which the aircraft was released to service.

1.6.2 The Lycoming O-320-D2J engine was installed in ZK-SBK on 2 October 2018 at zero hours since overhaul. At the time of the accident, the engine had run 823.35 hours.

1.6.3 The aeroplane had a current airworthiness certificate and the most recent annual review of airworthiness was performed on 18 December 2018.

1.6.4 No evidence was found of any mechanical or flight control system failure that may have contributed to the accident.

1.6.5 The student was flying an aircraft fitted with an analogue instrument panel when the accident occurred.

1.7 Meteorological information

1.7.1 The sky was predominantly clear of cloud with unlimited flight visibility.

1.7.2 Meteorological conditions were not a factor in this accident.

1.8 Aids to navigation

1.8.1 Nil.

1.9 Communications

1.9.1 The student made standard radio calls to the air traffic controller while operating in the Christchurch control zone and when departing controlled airspace to the south.

1.9.2 The training organisation's southern training area is within the Banks Peninsular Common Frequency Zone (CFZ).

1.9.3 Another pilot reported hearing an "operations normal" position report from ZK-SBK while it was operating in the Lake Ellesmere area.

1.9.4 Radio calls within CFZs are not formally recorded.

1.10 Aerodrome information

1.10.1 Nil.

1.11 Flight recorders

1.11.1 The aircraft was fitted with a flight navigation tracking product called V2 Track[4].

1.12 Wreckage and impact information

1.12.1 The aircraft wreckage was spread over a large area.

1.12.2 The fuselage, tail section, and engine came to rest inverted just beyond, and in line with, the impact crater.

1.12.3 The impact crater was 3.2 metres long by 2.5 metres wide with a maximum depth of 0.85 metre. The centre line of the crater lay along the bearing line of 330^{o} true.

1.12.4 Both wings were severed. The left wing was found 42 metres away from the aircraft fuselage, while the right wing was 27 metres away.

1.12.5 The upper engine cowling and some smaller aircraft parts were located up to 58 metres away.

1.12.6 Damage to the propeller indicated the engine was producing high power at the time of impact.

1.13 Medical and pathological information

1.13.1 The post-mortem examination determined the student died of injuries consistent with a high-energy impact.

1.13.2 There were no other relevant medical findings in the pathology and toxicological reports.

1.13.3 There was no evidence of any pre-existing medical conditions that could have resulted in pilot incapacitation or affected the student's ability to fly the aircraft.

[4] V2 Track transmits in-flight data packets at a user defined time interval to a cloud-based website. A user can see all flights as they progress or review them later. In this case the V2 was set to transmit every 10 seconds.

1.14 Fire

1.14.1 Nil.

1.15 Survival aspects

1.15.1 The accident was not survivable due to the high-energy impact forces.

1.15.2 The aircraft's emergency locator transmitter activated immediately.

1.16 Tests and research

Aircraft factors

1.16.1 The aircraft's vacuum pump was examined by a CAA aircraft engineer. The vacuum pump was not damaged. Its driveshaft was intact and could be turned freely by hand. The rotor vanes were also inspected and there was no excessive wear. The vacuum pump appeared to be serviceable. Failure of the vacuum pump will cause erroneous readings in some cockpit instruments.

1.16.2 The aircraft's alternative air system was also examined. The selector knob in the cockpit was found in the normal closed position. The selector control valve and its static port hole were examined, and both were noted to be serviceable.

1.16.3 Due to the high-energy impact, the cockpit instruments could not be forensically examined to obtain any useful readings or ascertain their serviceability.

Visual and sensory illusions

1.16.4 Many types of visual and sensory illusions can affect a pilot, particularly if flying visual flight rules (VFR) at night with reduced external visual references. Some of these are described in the CAA Good Aviation Practice (GAP) booklet *Night VFR* (refer to Figure 2).

1.16.5 The GAP booklet *Night VFR* also describes environmental features that can lead to pilot disorientation. Page 20, paragraph 6, states, "Large areas of water can be hazardous because of loss of horizon, lack of landmarks for situational awareness, and reflections of stars can contribute to disorientation".
All these features were present during the final right turn leading to the departure from controlled flight.

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Sensory illusions and spatial disorientation

During flight, as well as during time spent on the ground, we maintain our orientation in space and time through the subconscious integration of sensory information – from the eyes, ears, nose, skin and joints, and the 'vestibular' balance organs. Vision is the main sense used during flight, with vestibular (from the balance organs in the inner ear), and somatic (from the skin and the joints) senses playing a secondary role.

When flying at night, there is less visual information available to assist with orientation. This reduction in visual information has the potential to result in sensory illusions, and these illusions can be very powerful and disorientating. Sensory illusions are caused by a mismatch between the information that the brain receives from the different sensory organs.

Night flight sensory illusions include:

> The reduction in visual information has the potential to result in sensory illusions, and these illusions can be very powerful and disorientating.

- **The leans** – Generally, a situation where a balanced turn has been sustained for long enough that the body compensates and incorrectly perceives the turn as being level flight. On rolling out of the turn, the sensation is of banking in the opposite direction, even though the wings are level.
- **Somatogravic illusion** – When an aircraft accelerates in level flight, or during take-off, our vestibular organs are not able to distinguish between the acceleration and gravity. This can result in an illusion that the aircraft's attitude is more nose-high than it is. The pilot can incorrectly apply nose-down control inputs until the flight feels right – and the aircraft descends and impacts the ground.
- **Somatogyral illusion** – This is a false sensation of rotation. A classic example of this illusion is the 'graveyard spiral', where the illusion of an opposite-direction turn occurs after a pilot has returned to straight-and-level. The pilot can incorrectly adjust for the false rotation, and can enter a progressively tighter spiral in the opposite direction, resulting in aircraft breakup or ground impact.
- **Coriolis illusion** – Moving the head excessively, especially during in-flight turns, confuses the balance mechanism in the ears, and can produce a tumbling sensation.

Figure *2* GAP 'Night VFR' page 10 - Sensory Illusions and Spatial Disorientation

1.16.6 An Australian Transport Safety Bureau (ATSB) overview describes three different types of spatial disorientation (SD). The description of Type III SD is stated below. It closely resembles the scenario that available evidence suggests may have contributed to this accident.

"In Type III SD, the pilot experiences the most extreme form of disorientation stress. The pilot may be aware of the disorientation, but is mentally and physically overwhelmed to the point where they are unable to successfully recover from the situation. They may freeze at the controls, or make control inputs that tend to exacerbate the situation rather than effect recovery from it. The pilot may fight the

aircraft all the way to ground impact, never once achieving controlled flight. Such forms of disorientation are a result of breakdowns in the normal cognitive processes, possibly due to the overwhelming nature of the situation, especially if other factors such as fatigue and high workload are also present".

1.16.7 Appendix One contains weblinks to the GAP *Night VFR* booklet, the ATSB overview (above), and other night flying and visual illusions safety information.

1.17 Organisational and management information

1.17.1 Nil

1.18 Additional information

1.18.1 Nil

1.19 Useful or effective investigation techniques

1.19.1 Nil

2. Analysis

2.1 After the aircraft was established in the Lake Ellesmere training area it conducted a series of left and right turns. The V2 tracking information showed the first five turns were at angles of bank[5] (AOB) greater than the training organisation's night flying procedures recommended. Calculations estimated these AOBs to be between 20 and 30 degrees. The training organisation's night flying programme teaches, and has pilots demonstrate, their ability to conduct turns up 30^0 AOB (medium turns). However, students are taught that all night flying turns should be rate one[6] turns, except in the circuit. A rate one turn generally equates to an AOB of approximately 15 degrees.

It was not possible to ascertain why the pilot conducted the turns at angles of bank greater than rate one.

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[5] The angle between the wings of an aircraft (the lateral axis) and the natural horizon.

[6] Rate one turns are conducted at an AOB that equates to a rate of turn of 3^0 per second.

2.2 After completing this series of turns, the aircraft made a wide left turn and flew to the south end of the lake before conducting another wide left turn back to the north. At the north end of the lake, the aircraft started a wide right turn towards the east leading to a departure from controlled flight and the accident.

2.3 The aircraft started losing height as soon as the right turn was begun. During the last 30 seconds, the height loss and change of direction both increased exponentially until the aircraft impacted the sand spit in a steep nose-down spiral turn. The average rate of descent over this time was calculated to be approximately 4500 feet per minute (refer to Figure 3).

2.4 The final (right) turn was conducted away from the bright lights of Christchurch city towards the relative darkness of the Akaroa Peninsular and Pacific Ocean in the east. There would be very few significant visual lighting clues for the student to reference during the latter stages of this turn.

Absence of visual references can contribute to the onset of visual and sensory illusions. Sensory illusions caused by fluid movement in the ear's vestibular canal can be overwhelming. These illusions can occur regardless of a pilot's experience or the aircraft's instrument panel design.

Pilots are trained to closely monitor and scan their instruments to determine the aircraft's positional situation in these circumstances.

2.5 The student had flown all his previous night flights in a glass cockpit-equipped aircraft, but on the night of the accident, he flew ZK-SBK, which was equipped with an analogue cockpit.

It isn't possible to determine if the accident would have been prevented if the student had been flying a glass cockpit aircraft. However, the training organisation has introduced a requirement that all single engine night flight training be carried out in glass cockpit-equipped aircraft.

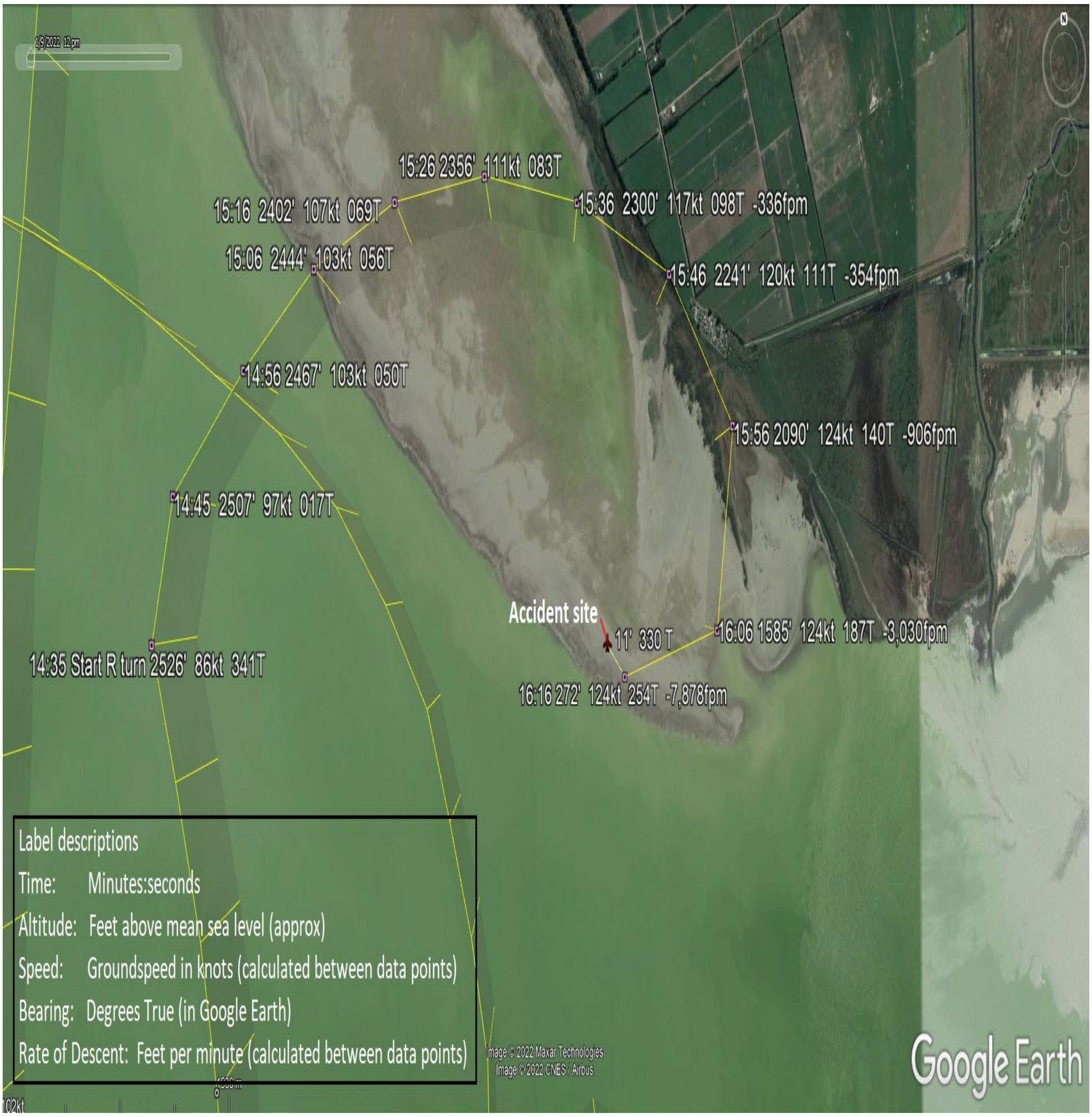

Figure 3. Final turn showing time, altitude, speed, true track and estimated rate of descent (Google Earth™)

2.6 The flight tracking information didn't provide any evidence to suggest the student recognised the situation, or took any action to correct the deteriorating situation.

2.7 The student completed his CPL cross-country flight test during the morning on the day of the accident flight. Examination situations are generally considered more stressful and require more mental demand than a training flight. It's likely that at the time of the night flight, the student was suffering a level of fatigue from the long duty day and the earlier flight test.

2.8 The effects of fatigue are a well-known threat to aviation safety. Fatigue can lead to the failure of pilots to recognise a rapidly changing environment, and it can slow and degrade a pilot's decision-making response times. Fatigue causes them to be more prone to making errors and even worse at detecting them, once they've happened.

2.9 To address this risk, the training organisation's fatigue management policy now includes the following scheduling rules:

- Students or instructors cannot be rostered to fly on the morning before a night flight booking
- Students or instructors must have a continuous 10-hour stand-down rest period between duties, and
- Following any exam or flight test, a student cannot undertake any further flying activity that same day, regardless of the outcome.

2.10 The student completed the training organisation's 'solo pre-signout checklist' declaration. Students' pre-flight briefings with an instructor include threat and error management and the IMSAFE[7] pilot fitness checklist. If an instructor has concerns during this briefing, they may cancel the flight.

2.11 Training aircraft numbers (slots) in the NZCH circuit are limited at night by a local Airways[8] agreement. No night circuit training slots were available for the student to book on the evening of the accident.

Duty instructors now schedule each night's flying programme and if necessary, book circuit training slots for low-time pilots.

2.12 The training organisation has also introduced a requirement that all their students must complete three hours of dual night flying training before flying solo at night.

[7] IMSAFE acronym: Illness, Medication, Stress, Alcohol/drugs, Fatigue, Eating (see CAA IM SAFE poster)

[8] Airways New Zealand Ltd is the certificated air traffic service provider in New Zealand.

3. Conclusions

3.1 The aircraft departed controlled flight and collided with terrain.

3.2 The student was appropriately licensed and assessed as competent, and current, to carry out the night solo flight.

3.3 The student assessed himself as fit to fly on a pre-flight checklist document.

3.4 There was no medical evidence of pilot in-flight incapacitation.

3.5 It was not possible to determine a conclusive cause of the accident. However fatigue, combined with visual and sensory illusions and low night flying time experience, were likely contributing factors in this accident.

3.6 The training organisation followed its policies and operations manual procedures and civil aviation rules at the time of the accident.

3.7 The accident was not survivable.

4. Safety actions

4.1 Since the accident the training organisation has reviewed and introduced several policies and procedures to further enhance pilot safety.

4.2 The CAA will publish a *Vector* article describing the threats of pilot fatigue and visual illusions, with specific reference to night flying (CAA Action 23A129).

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Appendix 1. Human Factors reference material

CAA GAP Night VFR booklet

ATSB An overview of spatial disorientation as a factor in aviation incidents

FAA Spatial Disorientation article

Flight Safety Australia - Spatial Disorientation (video)

ATSB Avoidable Accidents No. 7 Visual flight at night accidents