Australian Government

Australian Transport Safety Bureau

Uncontrolled flight into water involving Cessna 208B, VH-FAY

260 km north-east of Narita International Airport, Japan, on 27 September 2018

ATSB Transport Safety Report
Aviation Occurrence Investigation
AO-2018-065
Final – 18 March 2020

Released in accordance with section 25 of the *Transport Safety Investigation Act 2003*

Publishing information

Published by: Australian Transport Safety Bureau
Postal address: PO Box 967, Civic Square ACT 2608
Office: 62 Northbourne Avenue Canberra, Australian Capital Territory 2601
Telephone: 1800 020 616, from overseas +61 2 6257 2463 (24 hours)
Accident and incident notification: 1800 011 034 (24 hours)
Email: atsbinfo@atsb.gov.au
Internet: www.atsb.gov.au

Addendum

Page	Change	Date

Safety summary

What happened

The pilot of a Cessna 208B aircraft, registered VH-FAY (FAY), was contracted by the aircraft operator to ferry FAY from Jandakot Airport, Western Australia to Mississippi, United States. On the morning of 27 September 2018 local time, the aircraft departed Saipan International Airport, Northern Mariana Islands, for a planned flight to New Chitose Airport, Hokkaido, Japan. After climbing for about an hour, the aircraft levelled off at flight level (FL) 220.

After 2 hours 20 minutes flight time, the pilot contacted Tokyo Radio flight information service at the first mandatory reporting position. The aircraft passed the next reporting point at the same altitude, 1 hour 20 minutes later, but the pilot did not contact Tokyo Radio as expected. Tokyo Radio made repeated attempts to communicate with the pilot, without success. Having received no communications from the pilot for 4.5 hours, two Japan Air Self-Defense Force (JASDF) aircraft intercepted FAY. The pilot did not manoeuvre the aircraft in response, in accordance with international intercept protocols.

After about 30 minutes, the JASDF pilots observed FAY descend into cloud. The aircraft descended rapidly and disappeared from radar less than 2 minutes later. Within 2 hours, search and rescue personnel located the aircraft's rear passenger door. No other aircraft parts were located and the pilot was not found.

What the ATSB found

While the aircraft was in the cruise on autopilot, the pilot almost certainly became incapacitated and did not recover. About 5 hours after the last position report, without pilot intervention to select fuel tanks, the aircraft's engine stopped, likely due to fuel starvation. This resulted in the aircraft entering an uncontrolled descent into the ocean.

The cause of incapacitation could not be determined. While a medical event could not be ruled out, the pilot was operating alone in an unpressurised aircraft at 22,000 ft and probably using an unsuitable oxygen system, which increased the risk of experiencing hypoxia and being unable to recover.

What's been done as a result

The aircraft operator amended their operations manual to include additional guidance for international ferry flights. They also created an oxygen use guide and a specific risk assessment for positioning (ferry) flights.

Safety message

Operating unpressurised aircraft above 10,000 ft requires careful oxygen management and planning. Where an increased risk of hypoxia exists, good risk management practices should be used for flight planning. Because the effects of hypoxia can be insidious, training in recognition of early symptoms of hypoxia can increase the time available to react, descend and resolve any issues. The Flight Safety Australia (2014) article *Do not go gentle: the harsh facts of hypoxia* provides further information, including anecdotal experiences of hypoxia.

VH-FAY with full survey equipment installed

Source: Sid Mitchell, Aviation Spotters Online

Contents

The occurrence

What happened

The pilot of a Cessna 208B aircraft, registered VH-FAY (FAY), was contracted to ferry the aircraft from Jandakot Airport, Western Australia (WA), to Greenwood, Mississippi in the United States (US). The pilot planned to fly via the 'North Pacific Route' (Figure 1).

At 0146 Coordinated Universal Time (UTC)[1] on 15 September 2018, the aircraft took off from Jandakot Airport, WA, and landed in Alice Springs, Northern Territory at 0743. After landing, the pilot advised the aircraft operator that the aircraft had a standby alternator fault indication. In response, two company licenced aircraft maintenance engineers went to Alice Springs and changed the alternator control unit, which fixed the problem.

Late the next morning, the aircraft departed Alice Springs for Weipa, Queensland, where the pilot refuelled the aircraft and stayed overnight.

On the morning of 17 September, the pilot conducted a 1-hour flight to Horn Island, Queensland. About an hour later, the aircraft departed Horn Island with the planned destination of Guam, Micronesia. While en route, the pilot sent a message to the aircraft operator advising that he would not land in Guam, but would continue another 218 km (118 NM) to Saipan, Northern Mariana Islands. At 1003, the aircraft landed at Saipan International Airport.

The next morning, the pilot refuelled the aircraft and detected damage to the propeller anti-ice boot. The aircraft was delayed for more than a week while a company engineer travelled to Saipan and replaced the anti-ice boot.

Figure 1: North Pacific Route

Source: Aircraft operator – annotated by ATSB

At 2300 UTC on 26 September, the aircraft departed Saipan, bound for New Chitose Airport, Hokkaido, Japan. Once airborne, the pilot sent a message from his Garmin device, indicating that the weather was clear and that he had an expected flight time of 9.5 hours.

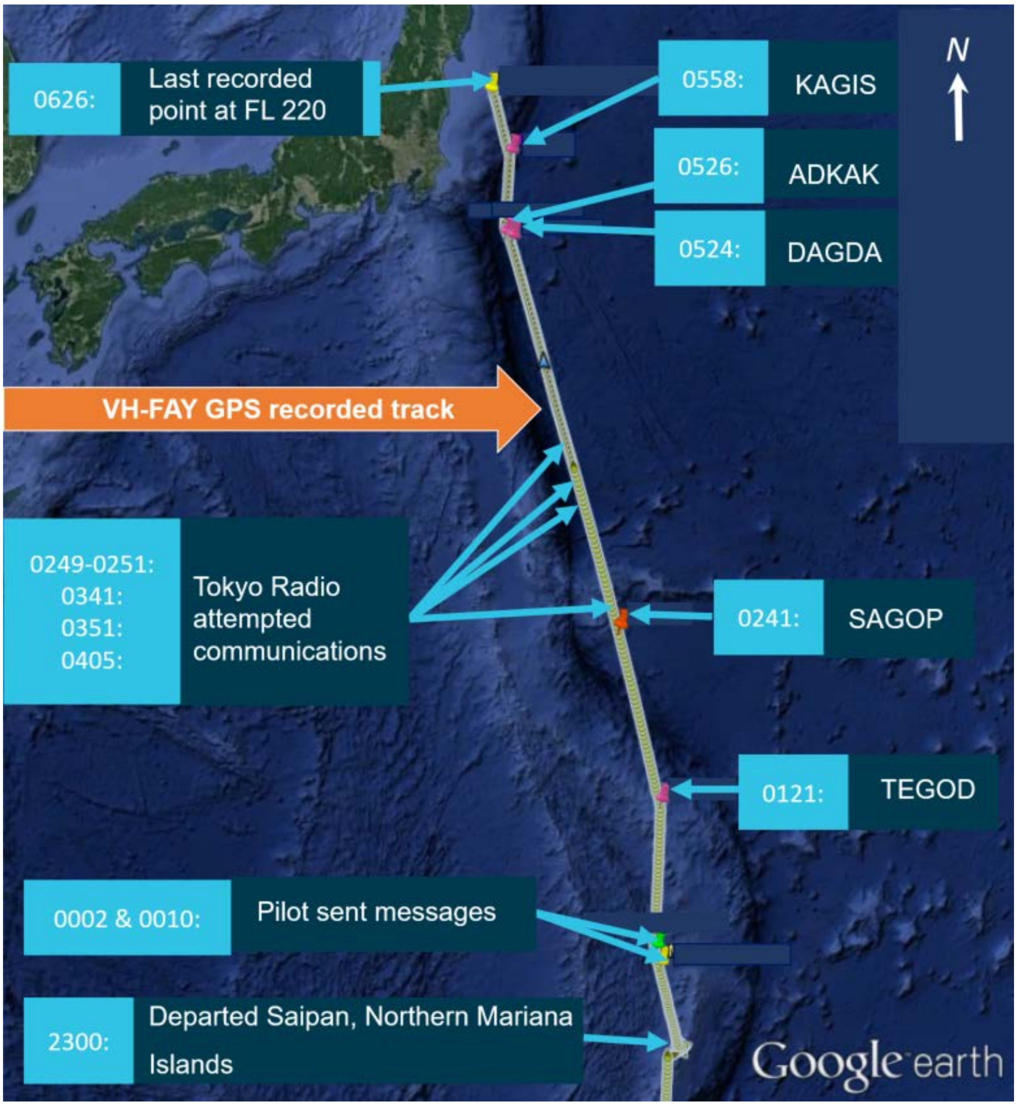
---

1 Coordinated Universal Time (UTC): the time zone used for aviation. Local time zones around the world can be expressed as positive or negative offsets from UTC.

About an hour after departure, the aircraft levelled out at flight level (FL) 220.[2] Once in the cruise, the pilot sent a message that he was at 22,000 feet, had a tailwind and the weather was clear. This was followed by a message at 0010 that he was at FL 220, with a true airspeed[3] of 167 kt and fuel flow of 288 lb/hr (163 L/hr).

At 0121, while overhead reporting point TEGOD (Figure 2), the pilot contacted Tokyo Radio flight information service[4] on HF radio. The pilot was next due to report when the aircraft reached reporting point SAGOP, which the pilot estimated would occur at 0244. GPS recorded track showed that the aircraft passed SAGOP at 0241, but the pilot did not contact Tokyo Radio as expected. At 0249, Tokyo Radio made several attempts to communicate with the pilot on two different HF frequencies, but did not receive a response. Tokyo Radio made further attempts to contact the pilot between 0249 and 0251, and at 0341, 0351 and 0405.

Figure 2: VH-FAY GPS recorded track



Source: Aircraft operator, Google Earth – annotated by ATSB

2 Flight level (FL): An aircraft's height above mean sea level when the pressure at sea level is 1013.2 hPa, called pressure altitude. FL 220 equates to 22,000 ft pressure altitude.

3 True airspeed (TAS): the speed of the aircraft relative to the air mass in which it is flying.

4 A flight information service is a form of air traffic service available to aircraft within a flight information region that provides information pertinent to safe and efficient conduct of flight including information on other potentially conflicting traffic.

About 4.5 hours after the pilot's last communication, two Japan Air Self-Defense Force (JASDF) aircraft intercepted FAY. The pilot did not respond to the intercept in accordance with international intercept protocols, either by rocking the aircraft wings or turning, and the aircraft continued to track at FL 220 on its planned flight route. The JASDF pilots were unable to see into the cockpit to determine whether the pilot was in his seat or whether there was any indication that he was incapacitated. The JASDF pilots flew around FAY for about 30 minutes, until the aircraft descended into cloud.

At 0626 UTC, the aircraft's GPS tracker stopped reporting, with the last recorded position at FL 220, about 100 km off the Japanese coast and 589 km (318 NM) short of the destination airport. Radar data showed that the aircraft descended rapidly from this point and collided with water approximately 2 minutes later. The Japanese authorities launched a search and rescue mission and, within 2 hours, searchers found the aircraft's rear passenger door (Figure 3). The search continued until the next day, when a typhoon passed through the area and the search was suspended for two days. After resuming, the search continued until 27 October with no further parts of the aircraft found. The pilot was not located.

Figure 3: Rear passenger door

Source: Aircraft operator

Context

Pilot information

According to information provided by the aircraft operator, the pilot had accrued over 13,600 hours of aeronautical experience and had conducted more than 200 ferry flights for various companies. The pilot held a valid US First Class Medical Certificate issued on 19 March 2018, with the restriction of vision correction. The 66 year-old pilot was reported by acquaintances to be a non-smoker, in good health for his age, and there was no evidence of any underlying medical conditions. In the nights before FAY departed from Saipan, the pilot had reportedly not slept well, but there was insufficient evidence to determine whether he could have been experiencing a level of fatigue that would affect performance.

The pilot was a Norwegian/American dual citizen with a United States (US) Airline Transport Pilot Licence issued in January 2018. For the ferry flight, a Certificate of Validation was issued by the Civil Aviation Safety Authority (CASA) on 14 September 2018 for a Commercial Pilot Licence (Aeroplane). This included the conditions that the flight 'must be conducted in accordance with [the aircraft operator's] operations manual and CASA legislative requirements pertaining to the flight planned route.' In January 2018, the pilot had ferried another Cessna 208B aircraft, VH-FHY (FHY) from Canada to Perth, WA.

Aircraft information

VH-FAY (FAY) was a Cessna Aircraft Company C208B aircraft manufactured in the US in 2001. At that time, the aircraft was issued with a Certificate of Airworthiness and an associated Airplane Flight Manual.[5]

The aircraft was fitted with a Honeywell TPE331-12JR engine and a Hartzell Propeller Inc. HC-B4TN-5QL/LT10891NK (De-ice) propeller under a Supplemental Type Certificate (STC). Also under an STC, the aircraft had been fitted with an improved landing gear axle. This increased the maximum landing weight from 3,856 to 4,082 kg and the maximum take-off weight (MTOW) from 3,969 to 4,110 kg. Flight Manual Supplements (FMS) to the Airplane Flight Manual had been issued for each of these modifications.

FAY was fitted with a Garmin GTN 750 GPS. Among other options, the aircraft's autopilot could be selected to 'Altitude hold', and lateral navigation mode could be selected to capture a GPS programmed flight plan.

The aircraft's last Maintenance Release[6] was issued on 7 September 2018 following completion of extensive maintenance in preparation for overseas operations. It was valid for 14 months or 230 hours. At issue, the aircraft had 9,269.8 hours total time in service and was approved in the aerial work category and for flight under the instrument flight rules (IFR).[7]

On the morning of 27 September, prior to departure from Saipan, the aircraft had a total of 9291.7 hours in service.

[5] The Airplane Flight Manual (AFM) is produced by the aircraft manufacturer and contains detailed information about operation of the aircraft.

[6] Maintenance release: an official document, issued by an authorised person as described in Regulations, which is required to be carried on an aircraft as an ongoing record of its time in service (TIS) and airworthiness status. Subject to conditions, a maintenance release is valid for a set period, nominally 100 hours TIS or 12 months from issue.

[7] Instrument flight rules (IFR): a set of regulations that permit the pilot to operate an aircraft in instrument meteorological conditions (IMC), which have much lower weather minimums than visual flight rules (VFR). Procedures and training are significantly more complex as a pilot must demonstrate competency in IMC conditions while controlling the aircraft solely by reference to instruments. IFR-capable aircraft have greater equipment and maintenance requirements.

Survey equipment

The aircraft was usually used for aerial survey work and had been fitted with an electromagnetic (EM) loop system under an Engineering Order[8] (EO) and an associated FMS had been issued. The system consisted of a copper cable loop suspended around the aircraft and supported by nose, wingtip and tail stingers with a transmitter mounted in the cabin. A receiver (bird) could be towed behind the aircraft on a cable, extended and retracted using a winch. The cable, bird and its cradle, and wingtip stingers had been removed in preparation for the ferry, and the tail stinger had been shortened but was still fitted to the aircraft. EM equipment in the cabin had also been removed, except for some fixed cables.

As the equipment was fitted under an EO, the aircraft had a Special Certificate of Airworthiness (CoA) that limited aircraft operation to the restricted category, for the purpose of aerial surveying.

The FMS for the EM loop limited the aircraft to a maximum operating airspeed of 161 kt and a maximum operating altitude of 20,000 ft, however, most of the equipment had been removed from the aircraft for the ferry. The design holder of the EM loop system advised the ATSB that exceeding the altitude limit had no safety implications in that configuration.

Although the aircraft was permitted to operate in IFR conditions, flight into known icing conditions was prohibited.

Ferry fuel tank and special flight permit

An aircraft that is not operated in accordance with its Type Certificate (and approved Supplementary Type Certificates) is not permitted to operate in foreign countries without a Special Flight Permit (SFP) and the approval of all countries the aircraft flies over or into.

For the ferry, FAY had been fitted with a ferry fuel tank under an engineering order with an associated FMS. The ferry fuel tank fitment meant that the aircraft no longer met the design requirements for the aircraft. Therefore the aircraft was required to operate under an SFP. An SFP was issued on 6 September 2018 by a person authorised by CASA to issue SFPs, but not to issue overweight approvals.

The aircraft Type Certificate Data Sheet (TCDS) stated that the aircraft was structurally satisfactory for ferry flight up to 130 per cent of the TCDS MTOW (which equates to 11,375 lb or 5,160 kg). However, without overweight approval, the aircraft was required to be operated not above the STC MTOW of 9,062 lb (4,110 kg). The ferry tank FMS stated that 'the ferry tank may only be able to be partially filled to stay within the aircraft 9062 lbs MTOW.'

Weight and balance

The loadsheet indicated that on departure from Saipan, the aircraft's take-off weight was 4,430 kg and it was loaded within the centre of gravity and structural limits.

Journey logs

The pilot completed journey logs for each flight sector, which included a daily inspection certification, take-off, landing and flight times, and fuel information. The pilot had also recorded engine condition trend monitoring information including the exhaust gas temperature (EGT) and RPM percentage. These are depicted in Table 1.

8 CASA defines an engineering order as the implementing document for a repair or modification and it contains all necessary instructions and references to carry out the task.

Table 1: Trend exhaust gas temperature (EGT) and engine RPM

Date	EGT (°C)	RPM (%)
15 September	657	100.5
16 September	658	100.4
17 September	658	100.2

Source: Aircraft operator

Operating the engine at 100.2 to 100.9 per cent was within the normal continuous engine speed allowable range. The FMS for the engine specified the maximum EGT as 650 °C. The engine manufacturer advised that operating at an average EGT of 658 °C relative to 650 °C increased fuel flow by about 5 lb (2.8 L) per hour under the conditions of the accident flight. The aircraft operator's head of airworthiness and maintenance control advised that no inspection was needed for the recorded temperature exceedances, which could be avoided if the pilot reduced RPM to 100 per cent.

The journey logs were sent to the operator each day, however they were not reviewed during the ferry flight.

Communications

Radio equipment

The aircraft was fitted with the following equipment:

- two VHF radios
- one HF radio
- a Spidertracks GPS connected via a switch on the instrument panel to a hot bus straight to the aircraft battery, so it would continue to operate in case of electrical failure
- one Artex G406-4 emergency locator transmitter fitted with a G shock and remote panel switch
- a satellite phone was installed in the aircraft, docked and with Bluetooth connection
- four personal locator beacons (MT410G) and one Kannad marine sport emergency position indicating radio beacon were on board, all of which needed to be manually activated.

The pilot had a Garmin inReach system from which he could send and receive messages, navigate and track flights and 'if necessary, trigger an SOS to get emergency help from a 24/7 global monitoring via the 100% global Iridium® satellite network.'

Push to talk

When the company licenced aircraft maintenance engineer (LAME) arrived in Saipan, the pilot advised him that the pilot-side push-to-talk (PTT) button had only been working intermittently and reported that he had been using the co-pilot-side PTT. The LAME cleaned and tested the button, which the pilot then verified was transmitting correctly.

Recorded data

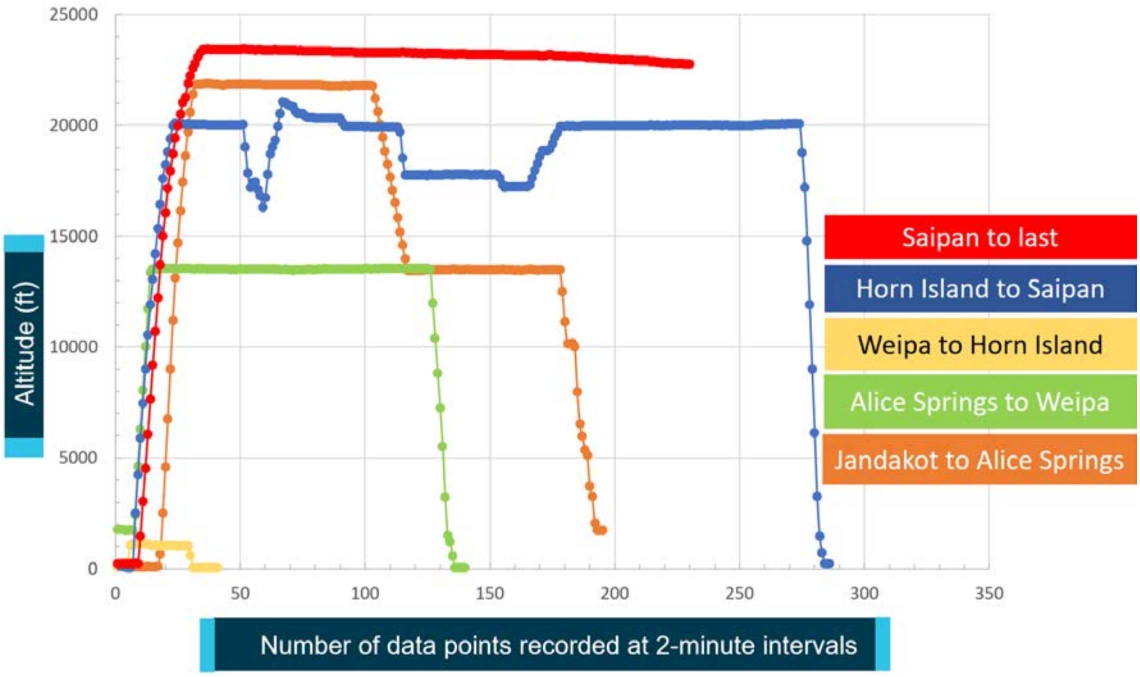
GPS data

The on-board Spidertracks and Garmin GPS devices recorded the aircraft's position and geometric altitude at 2-minute intervals. The recorded altitude of all sectors flown from Jandakot Airport to the last recorded position is shown in Figure 4. About half of the first leg, from Jandakot to Alice Springs, was flown at FL 210 before descending to FL 130, which was also the cruise altitude on the following sector to Weipa. On the flight from Horn Island to Saipan, having conducted a climb to FL 200, the pilot then made a descent over Papua New Guinea, possibly to avoid weather near Mount Hagen, before climbing and then maintaining FL 200.

The geometric altitude for the occurrence flight from Saipan showed a gradual descent from top of climb at 23,412 ft to the last recorded position at 22,770 ft. This was consistent with the aircraft flying into reducing temperature and barometric pressure. The corresponding radar data recorded pressure altitude at intervals of about 10 seconds and showed a constant altitude at 22,000 ft AMSL.

The pilot sent several messages from the Garmin device after departing Saipan and before the aircraft reached reporting point TEGOD. The last position recorded by the Spidertracks and Garmin devices was at 0626 UTC at FL 220. The aircraft took less than 2 minutes to descend from FL 220 to the ocean and there were no GPS recorded points below that altitude.

Figure 4: Geometric altitude of all flight sectors



Source: Spidertracks analysed by ATSB

Radar and ADS-B data

Japanese air traffic services recorded mode C radar and automatic dependant surveillance broadcast (ADS-B) data from FAY. Secondary surveillance radar (SSR) returns depend on an aircraft transponder's reply to an interrogation from the ground. In response to a mode C interrogation, the aircraft transmits an encoded return with the aircraft's selected SSR code and pressure altitude.

Radar data recorded the aircraft's position (in X and Y coordinates) from the ground radar site and pressure altitude (referenced to 1013 hPa and quantised to the nearest 100 ft) at approximately 10-second intervals. ADS-B data transmitted from FAY's GPS included the aircraft's altitude within about 25 ft.

The aircraft was recorded by radar at 22,000 ft at 0627:36 and there were five valid radar returns after that. The data showed that the aircraft descended from 22,000 to the last recorded position of about 11,500 ft in 62 seconds, with an increasing descent rate of up to 22,000 and 23,000 ft/min. That descent rate was less than the dive speed (V_D)[9] for the aircraft (250 kt calibrated airspeed), which corresponded to a vertical descent rate of about 25,300 ft/min.

9 An aircraft must be designed to be capable of diving to the design dive speed (V_D) without flutter, control reversal or buffeting.

Recorded audio transmissions

The ATSB obtained recorded audio of the pilot's transmissions on HF radio to Tokyo Radio and VHF transmissions while tracking across Australia. Comparative analysis of these was carried out with the aim of determining whether the pilot was likely to have been using a nasal cannula and/or affected by hypoxia in the final transmission. Indicators of hypoxia include timing of microphone keying, voice onset time and fundamental frequency range of the pilot's voice, but these could not be measured due to the noise in the HF channels. The pilot's communications with Tokyo Radio at TEGOD included some hesitation and a misstated time, but the tempo of the pilot's next transmission appeared normal and he corrected the time error. The ATSB was unable to make any conclusions based on the recorded audio.

Fuel

The aircraft was fitted with left and right wing tanks, which held a combined total of 1,257 L (2,225 lb) of usable fuel. The ferry tank held 924 L (1,635 lb) of usable fuel. The ferry tank was fitted under an engineering order with an associated FMS.

Based on the journey log and fuel dockets, the aircraft ferry and wing tanks were filled in Saipan on 18 September. Although the pilot had taxied the aircraft for maintenance, the fuel was likely close to full on departure. The LAME in Saipan had seen the pilot conduct a pre-flight fuel sample drain from the aircraft and check for contaminants, on the morning prior to departure.

There was no published fuel flow data for flight at FL 220, but the pilot reported an in-flight fuel consumption rate of 163 L/hr (288 lb/hr), which would have been relatively constant for the 6.4 hours in cruise. The aircraft took about 1 hour from taxi to reaching top of climb at 22,000 ft. The operations manual specified a planned fuel burn rate of 450 lb/hr in the climb and the design holder for the engineering orders estimated a taxi and climb fuel consumption of 353 lb. Given the pilot had previously started the aircraft and taxied for maintenance, an estimated fuel consumption for the taxi and climb was 400 lb. Based on these figures, the estimated total fuel used at the last recorded position was 1,241 L (2,196 lb), which was approximately the combined volume of the wing tanks.

Fuel transfer and imbalance

The fuel transfer protocol detailed in the ferry tank FMS was to conduct the take-off and climb to altitude using both aircraft main fuel tanks and, when established in the cruise, turn the left wing tank selector to off, as fuel in the ferry tank could only be transferred to the right wing tank. Two electric ferry tank pumps could be selected with different flow rates – 440 lb/hr (low) and 600 lb/hr (high). There was no gauge to indicate fuel quantity remaining in the ferry tank, and the pilot was required to monitor the fuel quantity of the right wing tank to ensure fuel was transferring as planned and that fuel was not venting overboard.

The FMS specified 200 lb as the maximum permitted fuel imbalance between the left and right tanks. When more severe sideslip is maintained (due to imbalance), the unusable fuel quantity increases. In this occurrence, if the left tank selector was set to off at the top of climb and the right tank was used until empty, it was possible to have a 900 lb imbalance.

In August 1998, the Cessna Aircraft Company conducted flight tests at the request of the US National Transportation Safety Board to determine controllability of the Cessna 208B at various airspeed and lateral fuel imbalance combinations. A Cessna 208B aircraft was flown to a maximum 600 lb imbalance, at airspeeds between 70 and 120 kt at flap settings of 0° and 20°. The maximum control wheel deflection attained was about 28°, of the maximum available 55° control wheel deflection. Control deflection versus lateral imbalance curves were derived from the test. The ATSB extrapolated the data and found that for a 900 lb imbalance, at the aircraft's likely airspeed, this equated to a control wheel deflection of +14°-17° and right aileron travel of +5-7°.

The aircraft manufacturer (now Textron Aviation) advised the ATSB that the autopilot servo was capable of driving the ailerons to the travel limits of 25° +4°/-0° up and 16° +1°/-0° down in the hangar. This indicated that if the aircraft had a fuel imbalance of 900 lb, there was adequate aileron control to maintain level flight at the aircraft's likely airspeed, however the autopilot force required to maintain this was not assessed. Photos from the JASDF of FAY in the final 30 minutes of the flight did not show any visible aileron deflection.

Weather

During the last 30 minutes of the flight, the aircraft was observed to be situated between two layers of cloud. The weather conditions that the aircraft likely encountered at FL 220 included strong south-westerly winds averaging about 50 kt, temperature about -15 °C and moderate turbulence. Moderate icing and light rain were present in cloud.

Supplemental oxygen

Because of reduced atmospheric pressure, operation of unpressurised aircraft in Australia above 10,000 ft requires supplemental oxygen.

Flight crew oxygen requirements

Australian Civil Aviation Order (CAO) 20.4 – *Provision and use of oxygen and protective breathing equipment*, stated:

> A flight crew member who is on flight deck duty in an unpressurised aircraft must be provided with, and continuously use, supplemental oxygen at all times during which an aircraft flies above 10 000 feet altitude.

CAO 108.26 – *System specification – oxygen systems* included that portable oxygen units may be used to meet the crew or passenger breathing requirements and that:

> …flight crew members may use nasal cannula manufactured under the name "Oxymizer", subject to the following conditions… (b) the flight crew members must use the nasal cannula only during private, aerial work, or charter, operations; (c) the aircraft must not operate above 18 000 feet altitude.

Further, it stated that 'Dispensing units provided in an aircraft operating above flight level 180 must be designed to cover the nose and mouth.'

Aircraft oxygen system

The aircraft was fitted with a 13-port oxygen system with a 3.312 cubic metre (116.95 cubic foot) capacity oxygen cylinder located in the fuselage tail cone. The cylinder had been tested and maintained in accordance with requirements, was within its 15-year life limit and had been filled with aviator breathing oxygen (ABO) prior to the aircraft's departure from Jandakot.

Oxygen from the cylinder was first reduced to 70 PSI by a pressure regulator and then by two altitude-compensating regulators located between the pressure regulator and oxygen supply lines, which automatically varied the flow of oxygen to the masks with changes in altitude. A remote shut-off valve in the overhead console was used to shut off the supply of oxygen to the system when not in use. A cylinder pressure gauge was located on the overhead console above the pilot's (and copilot's) seat.

A microphone-equipped Cessna mask with a vinyl plastic hose and flow indicator was stored under the pilot's seat. It was observed to be in its packaging (unused) when the aircraft was in Saipan.

On-demand system

The pilot had a battery-operated Mountain High (MH) Pulse-Demand™ Electronic Delivery System (EDS) O2D1 (single-person) model (Figure 5). The EDS unit supplied a measured pulse of oxygen at the beginning of each inhalation and was oxygen-compensating (increasing flow with altitude). The unit had audible and illuminating flow fault and apnoea alarms. A representative from Mountain High advised that although the ceiling of the MH EDS is 25,000 ft, at 22,000 ft it is at the maximum flow rate requirement for oxygen.

Figure 5: Mountain High Pulse-Demand Electronic Delivery System O2D1

Source: Mountain High

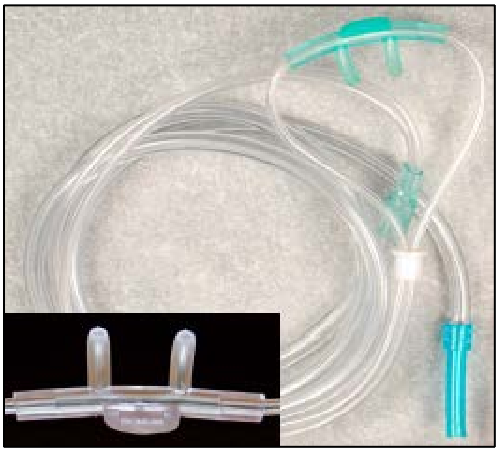
Cannula

The pilot preferred to use a nasal cannula for oxygen delivery and he intended to use it for the ferry flight. This was consistent with the supplied oxygen mask being unused before departing Saipan, despite two previous sectors above 18,000 ft. The pilot had also sent a message on the previous sector, indicating that he was using the cannula at 19,000 ft.

The ATSB could not establish the cannula model used for the ferry, however the MH EDS manual stated 'Use only the supplied MH EDS cannula, as other cannulas may not work properly with the EDS.' The standard MH nasal cannula (Figure 6) differed from the Oxymizer specified in CAO 108.26, which had a reservoir that stored oxygen during the exhalation then added it to the delivery during inhalation to increase oxygenation. Mountain High advised that the risks of wearing a cannula are:

- it is ineffective if the pilot has nasal congestion, is eating, talking or mouth-breathing
- it can come away from the nose, which would also trigger the apnoea alert.

Figure 6: Mountain High nasal cannula



Source: Mountain High

In-line regulator

The EDS was required to be operated with an oxygen inlet pressure between 16 and 20 PSI, which could be achieved with an in-line regulator (Figure 7). The MH EDS manual indicated that the flow of oxygen would be unnecessarily high between 20-30 PSI. The manual also included the warning that higher pressure 'will not only compromise the performance of the EDS, but is likely to damage the internal breathing sensor, rendering your EDS unit inoperable.' MH advised that pressures above 30 PSI would cause the valve to open up and result in the EDS working like a constant flow system. In this situation, the apnoea alert would sound out constantly until the oxygen supply was nearly depleted.

The pilot did not have an in-line regulator for the flight. At altitudes above 17,000 ft, the aircraft's system provided oxygen at 21.55 ± 2.5 PSI, which was higher than the EDS inlet pressure range. At 20,000 ft, this increased 24.45 ± 2.5 PSI. There was no data for the output pressure at 22,000 ft.

Figure 7: In-line regulator to connect EDS to aircraft oxygen outlet

Source: Mountain High

Mountain High aluminium cylinders

In his briefing before the aircraft departed Jandakot, the chief pilot understood that the pilot intended to plug his EDS directly into the aircraft system without an in-line regulator and was concerned about its effectiveness. Therefore, to ensure the pilot had an independent oxygen supply, the operator provided two MH aluminium (AL682) cylinders fitted with MH regulators, each of which had a maximum volume of 0.68 cubic metres (24.1 cubic feet) and a 'typical volume' of

0.63 cubic metres (22.1 cubic feet). The cylinders were filled with ABO and secured behind the copilot's seat, which the pilot could reach if he slid his seat backwards.

Flight above FL 180

The MH EDS manual advised that pilots operating above 18,000 ft should have a supplementary oxygen cylinder gauge and an emergency backup oxygen system. The manual also provided full cylinder duration figures up to its ceiling of 25,000 ft and cylinder duration graphs from which to calculate usable oxygen for altitudes up to 18,000 ft.

The FAA pilot safety brochure *Oxygen equipment: Use in General Aviation Operations* stated that the use of cannulas was restricted by US Federal Aviation Regulations to 18,000 ft 'because of the risk of reducing oxygen-blood saturation levels if one breathes through the mouth or talks too much.'

The aircraft operator's operations manual approved the use of the MH EDS O2D2 and MH standard aviation nasal cannula up to FL 180, above which pilots were required to use a constant flow mask.

Pulse oximeter

To aid in identifying the symptoms of hypoxia, the pilot had a pulse oximeter, which showed blood oxygen saturation levels based on reading from the finger. On a previous flight the pilot was observed only to use the oximeter intermittently.

The US Federal Aviation Administration (FAA) cautions against relying on pulse oximeters as the sole indicator of hypoxia because by the time the oxygen saturation levels fall, it may result in a level of hypoxia sufficient to cause impairment. Further, the haemoglobin oxygen saturation in blood passing through the finger may not reflect oxygen available to the brain.

Pilot's oxygen usage

An oxygen management plan from the pilot was not provided to the operator, however there were three sources of oxygen available to the pilot – the aircraft oxygen system and two aluminium cylinders, which were all filled prior to departure from Jandakot. It was not known which source the pilot used and when, but only one cylinder remained behind the copilot's seat prior to the aircraft departing Saipan. This suggests the pilot had used one cylinder during the flights to Saipan. The pilot had not refilled the aircraft or portable oxygen cylinders since commencing the ferry.

The ATSB estimated whether the pilot had sufficient oxygen to complete the sector. This was based on the time at various altitudes flown for all sectors up to the last recorded aircraft position, and the expected endurance of the available oxygen, filled to typical pressures, according to the manufacturer's documentation. The estimation was also based on using the available equipment as follows:

- oxygen was used at all altitudes above 10,000 ft
- the nasal cannula was used with the MH cylinders at all flight levels
- the aircraft system was used with a mask or cannula, with or without the EDS.

The pilot's actual equipment usage may have varied from these assumptions and it is acknowledged that oxygen usage can vary significantly between individuals, especially with on-demand systems. However, it represented realistic usage scenarios and approximate endurance for the available oxygen. Even when conditions of highest usage were considered, there should have been several hours of oxygen remaining at the completion of the sector to Japan.

Hypoxia

Hypoxia is the absence of an adequate supply of oxygen to the tissues. Hypobaric hypoxia is the most common form in aviation and is associated with breathing air at low barometric pressure. A deficiency in alveolar oxygen exchange due to low oxygen tension (partial pressure) of inspired air leads to inadequate oxygen supply to the blood and reduced oxygen available to the tissues.

Hypoxia can be prevented by pressurising the aircraft cabin or by breathing supplemental oxygen. However, hypoxia can still occur in unpressurised aircraft if, for example, the supply equipment fails and/or does not provide an adequate concentration of oxygen or if the supply is not managed appropriately. In an aviation context, acute hypobaric hypoxia is the 'most serious single physiological hazard during flight at altitude.' [10]

Signs and symptoms of hypobaric hypoxia include:

- darkening and restriction of the visual field and loss of peripheral vision
- increased heart rate, hyperventilation and light-headedness
- syncope (fainting/unconsciousness, pallor, sweating, nausea and vomiting)
- cyanosis (bluish colouration of the skin, nail beds and mucous membranes)
- impairment of mental performance and neuromuscular control, slowed reaction time
- muscular spasms

From 15,000 to 20,000 ft 'there is a loss of critical judgment and willpower…the subject is usually unaware of any deterioration in performance or indeed of the presence of hypoxia; it is this that makes the condition such a potentially dangerous hazard in aviation.' Above 20,000 ft these symptoms and signs become more pronounced. Involuntary jerks of the arms, loss of consciousness and convulsions occur, and after several minutes, death.

Physical activity, cold, illness and certain drugs increase the onset speed and severity of hypoxia.

US FAA Advisory Circular AC_61-107B *Aircraft operations at altitudes above 25,000 feet mean sea level or Mach numbers greater than .75* indicated that while the signs of hypoxia can be detected in an individual by an observer, signs are not a very effective tool for hypoxic individuals to use to recognize hypoxia in themselves. The circular carried the following warning:

> A common misconception among pilots is that it is easy to recognize the symptoms of hypoxia and to take corrective action before becoming seriously impaired. While this concept may be appealing in theory, it is both misleading and dangerous for crewmembers.

The Skybrary *Operator's Guide to Human Factors in Aviation Briefing Note* defined the fourth, or critical stage of hypoxia as above 18,000 ft. It stated:

> Above this altitude, complete incapacitation can occur with little or no warning. All senses fail, and a pilot will become unconscious within a very short period of time. No stimuli such as the radio will be able to help a pilot suffering from hypoxia, especially [rapid onset] fulminant hypoxia, above 5,500 meters (18,000 feet).

A less common form of hypoxia in an aviation context is anaemic hypoxia, caused by carbon monoxide poisoning. This is most commonly associated with piston engine aircraft, in drawing air for cabin heating over a damaged or defective exhaust system. Turbine engines produce up to two orders of magnitude lower carbon monoxide emissions than piston engines and utilise compressor bleed air as opposed to an exhaust heat exchanger. In addition, in 1984, the US National Transportation Safety Board investigated the possible effect of engine oil bleed air contamination on pilot incapacitation, from Garrett TPE 331 engines. It was concluded that such contamination was not likely to occur.

Time of useful consciousness

The FAA circular referenced above (AC_61-107B) defined the time of useful consciousness (TUC) as 'the period of time from interruption of the oxygen supply, or exposure to an oxygen-poor environment, to the time when an individual is no longer capable of taking proper corrective and

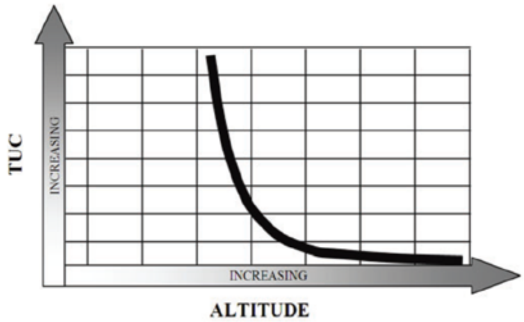
---

10 Gradwell DP, Rainford DJ 2006, Ernsting's aviation medicine, Edward Arnold (Publishers) Ltd London, Chapter 3.

protective action.' There are significant variations in TUC between individuals, and it does not mean that everyone will be capable of performing complex tasks in a challenging environment for the duration.

The circular included a graph showing decreasing TUC with increasing altitude (Figure 8). At 22,000 ft, the TUC was 10 minutes, or 5-6 minutes following rapid decompression. However, it goes on to caution that slow decompression is as dangerous as, or more dangerous than, a rapid decompression, as the resultant hypoxia may be unrecognized by the pilot. The circular also carried the warning: 'The TUC *does not* mean the onset of unconsciousness. Impaired performance *may be immediate.*'

Figure 8: Times of useful consciousness versus altitude



ALTITUDE	TUC/EPT	Following Rapid Decompression
18,000	20–30 min	10–15 min
22,000	10 min	5–6 min
25,000	3–5 min	1.5–2.5 min
28,000	2.5–3 min	1–1.5 min
30,000	1–2 min	30 s–1 min
35,000	30 s–1 min	15–30 s
40,000	15–20 s	Nominal
43,000	9–12 s	Nominal
50,000	9–12 s	Nominal

Source: FAA AC 61-107B

Pilot exposure and training for high altitude flying

There was evidence from previous flights that the pilot had some exposure to operating at higher altitudes. The pilot also held a valid US type rating for a Bombardier Challenger aircraft which had a service ceiling above FL 250. Under US Code of Federal Regulations Part 61.31 (g), this required completion of ground theory training including the effects, symptoms and causes of hypoxia and any other high-altitude sickness. The pilot had completed theoretical hypoxia awareness training and reported being aware of his own initial signs of hypoxia.

Altitude-induced decompression sickness

Flying unpressurised aircraft above 18,000 ft can not only induce hypoxia, but also result in altitude-induced decompression sickness (DCS). This is the formation of nitrogen bubbles in different areas of the body due to exposure to reduced barometric pressure. According to the FAA pilot safety brochure on decompression sickness, in most cases of DCS, the bubbles form in the joints, but in 10-15 per cent of cases, neurological manifestations occur. These can include similar symptoms to hypoxia such as confusion, seizures and unconsciousness.

While most cases occur at or above 25,000 ft, the risk of DCS increases with exposure to altitudes above 18,000 ft.

Oversight of the ferry flight

The aircraft operator's Air Operator Certificate (AOC) was for aerial work and as such, it was not a regulatory requirement to have a formal safety management system. Despite this, the aircraft operator had implemented a health, safety and environmental operating management system (HSE-OMS) that applied to their aviation activities, most of which were low-level survey operations.

FAY was routinely ferried to new surveying locations with its specialised equipment installed. Although ferry flights were classed as private operations, they were normally carried out by company pilots, operating under the AOC. The flights were conducted in accordance with the standard operating procedures and the chief pilot was responsible for operational matters affecting the safety of flying operations. However, following the successful ferry of FHY from Canada to Western Australia by the contract pilot 6 months earlier, the operator elected to re-engage the contract pilot to ferry FAY to the US.

Risk assessment for the ferry flight

The operator initially conducted a gap analysis to identify any changes that had occurred since the ferry of FHY. It identified several actions, including the need to audit the pilot's qualifications, conduct a familiarisation flight and briefing on the aircraft and fitments, and for flight monitoring by company staff.

At the planning stage of the FAY ferry, the primary concerns of the operator were around managing:

- long sectors over water – fatigue, lack of alternate landing areas and distance from search and rescue assistance
- single-pilot operation – the operator required their own ferry flights to be conducted with two crewmembers, but the contracted ferry pilot preferred to operate alone
- routing – including consideration of security in countries to be overflown.

In accordance with the HSE-OMS, the operator then conducted a risk assessment for the ferry flight. The operator's risk matrix guidelines included:

> The Risk Matrix must be used with good judgment, applying the following recommendations:
>
> - Make use of the experience of several people, with a broad range of experience and backgrounds.
> - Within the defined context, the relevant hazards should be identified and documented in the hazard libraries.
> - For an identified hazard, the potential consequences (severity) are determined first. A hazard can have a consequence in several categories…
> - Risk must be assessed in the context of an activity as hazards manifest themselves differently in different environments or conditions…

The aviation manager reported that he had done the risk assessment based on what the company had experienced in previous ferries and general risk assessment from their operations. The quality assurance manager and flight operations administrator were involved in the assessment process. He also obtained input from the company's aviation specialist in Canada, who had been involved with the risk assessment for the previous ferry (of FHY). The assessment report was then provided through to their HSE manager.

The HSE manager commented that normally they would get flight operations personnel involved; he, the chief pilot, the aviation manager, a ferry pilot, and a couple of other pilots would form a team. However, the HSE manager had been on vacation during the ferry risk assessment and had not been involved in the process.

The risk assessment identified 32 hazards including one relating to hypoxia:

> Unconscious pilot due to oxygen starvation [resulting in] uncontrolled flight into terrain.

It was initially rated as moderate and assessed as unlikely to occur. The nominated control to reduce risk was that there was an oxygen system fitted to the aircraft, with no resultant change to the risk rating (or likelihood). Consideration of specific operational or technical factors that could contribute to hypoxia were not included in the risk assessment. Nor was any form of pilot incapacitation other than hypoxia.

Nearly half of the identified hazards nominated the pilot's experience (having conducted over 200 ferry flights, including multiple recent Pacific crossings) as one of, or the only risk control. The assessment did not detail whether the pilot had considered the hazards or associated risks, or how he proposed to mitigate them. However, the day before FAY departed Jandakot, the ferry pilot reviewed the risk assessment in conjunction with the operator and suggested additional risks, including road transport, 'poor decision making due client pressure,' and access to food and medical support. The chief pilot and a senior company pilot later outlined to the ATSB that they assessed the pilot as being 'quite organised and competent', albeit with a clear preference for doing things his own way.

Aircraft operator and pilot agreement

The contract between the pilot and aircraft operator for the ferry detailed the responsibilities of each party, and stipulated how the aircraft was to be operated, including the requirement to adhere to standard operating procedures as specified in the operations manual.

The 'International Operations' section of the operations manual included requirements for approvals, permits and documentation associated with travelling to foreign countries as well as flight planning, flight following and emergency equipment. In the agreement between the aircraft operator and the contract pilot, most of these responsibilities had been assigned to the pilot to manage. Of significance, the section stated that 'In general, the Chief Pilot will manage an overseas operation. Close liaison between the aircrew and the Chief Pilot or their delegate is essential.'

The chief pilot had commenced with the operator on 28 August 2018, two weeks before FAY departed Jandakot on the ferry flight. The chief pilot had previously conducted ferry flights for a different operator, but was inexperienced on the C208 aircraft type. Additionally, because the ferry was assigned to a contract pilot, the chief pilot reported having been informed that he was not required to have involvement in the conduct of the operation, other than briefing the ferry pilot prior to departure.

Along with the risks inherent to the type of operation, the aircraft operator had considered the additional threats posed by financial incentive to complete the ferry as expeditiously and cost-effectively as possible. To this end, the contract included that the pilot would be paid for any days delayed on the ground to reduce pressure to continue the flight in adverse conditions. The pilot was responsible for fuel, oil and other en-route costs such as accommodation and food.

Pre-flight briefing and familiarisation flight

The day before the ferry flight departed from Jandakot, the pilot completed an aircraft familiarisation flight with a senior company pilot experienced in ferry flights, and a briefing with the chief pilot. The familiarisation flight focused on aircraft handling and use of the ferry tank fuel. The chief pilot's briefing was primarily about the aircraft's minimum equipment list and safety equipment. These measures had been identified in the gap analysis but not included in the risk assessment.

When the chief pilot briefed the ferry pilot, he was concerned about the pilot's intention to connect his EDS unit to the aircraft oxygen system without the requisite regulator. To address the concern, he provided the pilot with the two portable oxygen cylinders that were appropriate for use with the pilot's equipment. The risk assessment did not include the pilot's oxygen management plan and further risk assessment was not done to assess the effect of the additional oxygen sources.

Flight following

The gap analysis indicated that company operations staff would be responsible for flight following. As required by the contract, the pilot sent the flight plan and journey logs to the operator each day, however they were not reviewed by the operator until after the aircraft disappeared from radar. The logs showed the pilot consistently operated the aircraft engine above the exhaust gas temperature (EGT) limit of 650 °C. Additionally, on the first sector to Alice Springs, the aircraft was flown at 21,000 ft and the final sector from Saipan was at 22,000 ft. Operations staff did not contact the pilot about exceeding the 20,000 ft limit.

Flight plan

The flight plan that the aircraft operator obtained, which was submitted for the planned flight from Saipan to New Chitose Airport, showed the flight planned altitude as FL 250, total estimated elapsed time of 10 hours and 15 minutes and (fuel) endurance of 9 hours and 30 minutes. The discrepancy with the planned flight time exceeding the endurance may have been a transposition error by the pilot, however neither this, the lack of alternates, nor the planned altitude in excess of the 20,000 ft limit was identified or amended prior to departure.

The flight plan obtained by Japan Civil Aviation Bureau was sent from Honolulu at 0507 UTC on 26 September, before the aircraft departed Saipan. That flight plan had a planned cruising level of FL 220 and a total estimated elapsed time of 8 hours and 53 minutes.

Summary of operational oversight

The aircraft operator had processes in place to identify and manage the risks associated with the ferry flight. This included conducting a gap analysis and risk assessment, familiarisation flight and pre-flight briefing, which identified the potential issue with pilot's intended use of the oxygen system.

The operator also relied on the pilot's extensive ferry experience to bring level of safety to the ferry flight. However, many of the risk controls relied solely on the pilot's experience and did not provide any detail on the steps the pilot had taken to manage those risks. The flight also took place outside of the company's standard procedures and without the normal level of oversight from operations personnel, both of which could have provided an additional opportunity to identify and manage the hazards associated with the ferry flight.

Previous occurrences

ATSB research publication *Pilot Incapacitation – Analysis of medical conditions affecting pilots involved in accidents and incidents (2007)*, reviewed occurrences recorded by the ATSB from 1 January 1975 to 31 March 2006. It identified three cases of hypoxia, which was 3 per cent of the medical/incapacitation events. One of those was a Beech Super King Air aircraft (VH-SKC) near Burketown, Queensland on 4 September 2000. The ATSB investigation report (200003771) assessed that the incapacitation of the pilot and seven passengers was probably due to hypobaric hypoxia due to operating at high cabin altitude and not receiving supplemental oxygen. The report also identified that all the fatal accidents where medical conditions or incapacitation occurred were single-pilot operations where there was no second pilot on board who could assume control of the aircraft and prevent an accident.

The ATSB investigated an incapacitation event involving a Raytheon Aircraft Super King Air 200, VH-OYA, which occurred on 21 June 1999 (199902928). As the aircraft climbed through 10,400 ft, the pilot inadvertently selected the 'bleed air off', which prevented the aircraft from pressurising. As the aircraft reached the planned cruising altitude of FL 250, the aircraft deviated from the assigned track and the pilot was observed repeatedly attempting to program the GPS. Shortly afterwards, the pilot lost consciousness. The passenger in the co-pilot seat took control of the aircraft and conducted an emergency descent, during which the pilot regained consciousness.

The investigation findings included that hypobaric training did not provide an effective defence to ensure the pilot (or passengers) would identify the onset of hypoxia.

ATSB investigation AO-2014-134: *Flight crew incapacitation involving a Reims F406, VH-EYQ near Emerald Airport, Qld on 1 August 2014*. The pilot and navigator were planning to conduct a survey operation at FL 240. The aircraft was unpressurised but fitted with an oxygen system. Having selected the oxygen supply on and donned oxygen masks, passing about FL 180, the pilot noticed the blood saturation level reporting on his oxygen pulse meter was 77 per cent instead of above 90 per cent. In a hypoxic state, the pilot worked to rectify a problem with his oxygen system connection with assistance from the navigator and air traffic control. In this case, the pilot subsequently commented that his hypoxia awareness training had aided his appreciation of his symptoms and effects of hypoxia.

On 23 September 2012, a Metro 3 aircraft, VH-SEF, failed to pressurise on climb (ATSB investigation AO-2012-127). Passing FL 140, the captain started to feel the effects of hypoxia, donned an oxygen mask, and the first officer took over flying the aircraft and conducted an emergency descent to 10,000 ft.

Safety analysis

Introduction

After departing Saipan and climbing for about an hour, the aircraft levelled off at flight level (FL) 220. An hour later, the pilot made a mandatory position report on HF radio and then no subsequent communications. About 5 hours after the position report, while maintaining FL 220 and the flight planned route, the aircraft descended to the ocean. No wreckage other than a part of the aircraft door was recovered and the pilot was not found, limiting the evidence available.

The analysis will consider reasons for the pilot's lack of any further communication and the aircraft's subsequent descent. The investigation identified some operational factors that increased the pilot's risk of experiencing hypoxia. These factors are explored in detail below.

Pilot incapacitation

The absence of any communication by the pilot after reporting at position TEGOD was almost certainly a result of pilot incapacitation. He did not make any further mandatory position reports, or respond to repeated attempts by Tokyo Radio to communicate on HF radio. The pilot had several alternative means of communication available in case of HF radio failure or failure of the aircraft's electrical system. He would have been able to communicate using one of those means if not incapacitated, as demonstrated by having successfully sent messages from his standalone Garmin device prior to reaching TEGOD.

Additionally, the pilot did not respond in accordance with international intercept protocols, either by rocking the aircraft wings or turning, when intercepted by two Japan Air Self-Defense Force (JASDF) aircraft. The JASDF pilots were unable to see into the cockpit to confirm whether the pilot of VH-FAY was visibly incapacitated.

No evidence was available from which to determine the cause of incapacitation. The two most likely mechanisms for incapacitation were due to the pilot experiencing a medical event or hypoxia. Although the pilot had a valid medical certificate and was reportedly in good health, a medical event could not be ruled out. Similarly, the pilot's last communications with Tokyo Radio were not of adequate sound quality to determine whether the pilot was affected by hypoxia at that time. In any case, there was ample time after TEGOD for the pilot to experience hypoxia and be unable to recover at the cruise altitude, before the aircraft reached the next reporting point.

With the pilot incapacitated, the aircraft continued on autopilot. The aircraft's track and altitude were consistent with the flight director selected to hold flight level (FL) 220 and to follow the GPS programmed track.

Fuel starvation and uncontrolled descent

About 5 hours after the pilot's last transmission, the JASDF aircraft radar showed FAY start to descend at an increasing rate, which was indicative of engine power loss. In the absence of pilot intervention, the power loss would have resulted from either engine failure or fuel starvation. An engine failure could not be ruled out, however this would had to have occurred in addition to pilot incapacitation, and the likelihood of both these events occurring in the same flight was considered to be low. The engine power loss was therefore considered more likely to have resulted from fuel starvation.

The estimated fuel used at the commencement of the descent was significantly less than the total fuel carried. However, as the pilot almost certainly became incapacitated relatively early in the flight, he would therefore not have been able to manually alter the fuel state after that point. It was possible to have starved the engine of fuel around the descent point by switching to the right tank and using some or all of the ferry tank (and venting some). However, this would have resulted in a fuel imbalance that was not evident in photos of the aircraft taken shortly before its descent. Given that the estimated fuel used was approximately equal to the usable fuel in the wing tanks, it was more likely that the wing tanks were selected for the duration and this usable fuel was exhausted, leaving the ferry tank full.

The aircraft's last computed descent rate was below the dive speed for the aircraft, and was therefore indicative of an uncontrolled descent, rather than an in-flight breakup. There was no recorded data of the aircraft's collision with the water, however the descent profile and wreckage indicated that the collision with water was not survivable.

Increased risk of experiencing hypoxia

In exploring the potential reasons for pilot incapacitation, there were several operational factors identified that increased the pilot's risk of experiencing hypoxia and being unable to recover.

The pilot elected to fly solo at FL 220 where, without adequate oxygen supply, the time of useful consciousness (TUC) was in the order of 5-6 minutes. This was limited compared to FL 180, for example, where the TUC was two to three times longer.

The pilot had undertaken a hypoxia awareness course and reportedly knew the initial symptoms that presented in himself, which would aid in identifying and mitigating against the risk of hypoxia. However, particularly above FL 180, impairment and incapacitation can occur quickly, with little or no warning, rendering a person unable to take action to recover. The pilot also had a pulse oximeter to monitor blood oxygen saturation, but had been observed on a previous flight to use it intermittently rather than continuously. Given the limited TUC, had the pilot followed a similar regime on this flight, it may have resulted in insufficient time to alert the pilot to decreasing saturation levels. The pilot elected not to have a second pilot on board, as offered by the operator, which would have provided an additional risk control in assisting to identify the signs of hypoxia in each other and enable recovery action, as illustrated by previous occurrences. This would be especially pertinent at altitudes where there is limited TUC.

There was adequate oxygen on board for the flight, however the pilot was probably using a nasal cannula connected to the pilot's electronic pulse-demand system (EDS) at all flight levels, as indicated by the fact that the Cessna mask was unused by the time the aircraft was in Saipan, despite having flown above FL180. This increased the risk of reduced oxygen-blood saturation levels.

The pilot had also indicated his intention to connect the EDS to the aircraft system without the in-line regulator that was required to ensure the EDS operated within its limits. At FL 220, this had the potential for the pilot to receive inadequate oxygen supply or for the EDS to be rendered inoperative, resulting in higher oxygen consumption than anticipated. However, it is noted that the pilot had the Cessna mask available which, if used with the aircraft system, would have mitigated this risk.

Findings

From the evidence available, the following findings are made with respect to the uncontrolled flight into water involving a Cessna Aircraft Company 208B, registered VH-FAY, that occurred 260 km north-east of Narita International Airport, Japan, on 27 September 2018. These findings should not be read as apportioning blame or liability to any particular organisation or individual.

Contributing factors

- During the cruise between Saipan and New Chitose, the pilot very likely became incapacitated and could no longer operate the aircraft.
- The aircraft's engine most likely stopped due to fuel starvation from pilot inaction, which resulted in the aircraft entering an uncontrolled descent into the ocean.

Other factors that increased risk

- The pilot was operating alone in the unpressurised aircraft at 22,000 ft and probably not using the oxygen system appropriately, which increased the risk of experiencing hypoxia and being unable to recover.

Safety actions

Whether or not the ATSB identifies safety issues in the course of an investigation, relevant organisations may proactively initiate safety action in order to reduce their safety risk. The ATSB has been advised of the following proactive safety action in response to this occurrence.

Aircraft operator

As a result of this occurrence, the aircraft operator has advised the ATSB that they are taking the following safety actions:

Risk assessment and standard procedures

The aircraft operator reviewed their risk assessment processes and the standard operating procedures for conduct of ferry flights. As a result, they amended the guidance for international ferry operations in their operations manual including: maximum sector length, fuel planning, mandating two-crew operations, oxygen planning, management and training, operating altitude limitations, and use of contract pilots.

Oxygen use guide

The aircraft operator also created an oxygen use guide and a specific risk assessment for positioning (ferry) flights.

General details

Occurrence details

Date and time:	27 September 2018 – 0626 UTC	
Occurrence category:	Accident	
Primary occurrence type:	Collision with terrain	
Location:	260 km NE of Narita International Airport, Japan	
	Latitude: 37° 41.55' N	Longitude: 142° 2.47' E

Pilot details

Licence details:	US FAA Airline Transport Pilot Licence, issued 22 January 2018
Endorsements:	unknown
Ratings:	Single engine and multi-engine aeroplane, Instrument rating
Medical certificate:	Class 1, issued 19 March 2018
Aeronautical experience:	Approximately 13,600 hours
Last flight review:	19 May 2018 (instrument flight rating renewal)

Aircraft details

Manufacturer and model:	Cessna Aircraft Company 208B	
Registration:	VH-FAY	
Operator:	CGG Aviation	
Serial number:	208B0884	
Type of operation:	Private – Ferry	
Departure:	Saipan, Federated States of Micronesia	
Destination	New Chitose Airport, Hokkaido, Japan	
Persons on board:	Crew – 1	Passengers – 0
Injuries:	Crew – 1 Fatal	Passengers – 0
Damage:	Destroyed	

Sources and submissions

Sources of information

The sources of information during the investigation included the:

- Aircraft operator and maintainer
- Aircraft engineer and design holder
- Japan Transport Safety Board
- Civil Aviation Safety Authority
- Bureau of Meteorology
- Honeywell
- Textron Aviation
- United States National Transportation Safety Board.

References

Campbell RD, Bagshaw M 2002, *Human performance and limitations in aviation*, Blackwell Science Ltd.

Gradwell DP, Rainford DJ 2006, *Ernsting's aviation medicine*, Edward Arnold (Publishers) Ltd London, Chapter 3.

Newman, DG 2004, *Flying fast jets: Human factors and performance limitations*, CRC Pres LLC.

Submissions

Under Part 4, Division 2 (Investigation Reports), Section 26 of the *Transport Safety Investigation Act 2003* (the Act), the ATSB may provide a draft report, on a confidential basis, to any person whom the ATSB considers appropriate. Section 26 (1) (a) of the Act allows a person receiving a draft report to make submissions to the ATSB about the draft report.

A draft of this report was provided to the aircraft operator, aircraft maintainer, aircraft insurance assessor, Civil Aviation Safety Authority, Japan Transport Safety Board, US National Transportation Safety Board, Textron Aviation, Honeywell, Thomson Design and Mountain High.

Submissions were received from the Japan Transport Safety Board, Honeywell, aircraft insurance assessor, aircraft operator, Thomson Design and Mountain High. The submissions were reviewed and, where considered appropriate, the text of the report was amended accordingly.

Australian Transport Safety Bureau

The ATSB is an independent Commonwealth Government statutory agency. The ATSB is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers. The ATSB's function is to improve safety and public confidence in the aviation, marine and rail modes of transport through excellence in: independent investigation of transport accidents and other safety occurrences; safety data recording, analysis and research; fostering safety awareness, knowledge and action.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia that fall within the ATSB's jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to operations involving the travelling public.

The ATSB performs its functions in accordance with the provisions of the *Transport Safety Investigation Act 2003* and Regulations and, where applicable, relevant international agreements.

Purpose of safety investigations

The object of a safety investigation is to identify and reduce safety-related risk. ATSB investigations determine and communicate the factors related to the transport safety matter being investigated.

It is not a function of the ATSB to apportion blame or determine liability. At the same time, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner.

Developing safety action

Central to the ATSB's investigation of transport safety matters is the early identification of safety issues in the transport environment. The ATSB prefers to encourage the relevant organisation(s) to initiate proactive safety action that addresses safety issues. Nevertheless, the ATSB may use its power to make a formal safety recommendation either during or at the end of an investigation, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation.

When safety recommendations are issued, they focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on a preferred method of corrective action. As with equivalent overseas organisations, the ATSB has no power to enforce the implementation of its recommendations. It is a matter for the body to which an ATSB recommendation is directed to assess the costs and benefits of any particular means of addressing a safety issue.

When the ATSB issues a safety recommendation to a person, organisation or agency, they must provide a written response within 90 days. That response must indicate whether they accept the recommendation, any reasons for not accepting part or all of the recommendation, and details of any proposed safety action to give effect to the recommendation.

The ATSB can also issue safety advisory notices suggesting that an organisation or an industry sector consider a safety issue and take action where it believes it appropriate. There is no requirement for a formal response to an advisory notice, although the ATSB will publish any response it receives.

Terminology used in this report

Occurrence: accident or incident.

Safety factor: an event or condition that increases safety risk. In other words, it is something that, if it occurred in the future, would increase the likelihood of an occurrence, and/or the severity of the adverse consequences associated with an occurrence. Safety factors include the occurrence events (e.g. engine failure, signal passed at danger, grounding), individual actions (e.g. errors and violations), local conditions, current risk controls and organisational influences.

Contributing factor: a factor that, had it not occurred or existed at the time of an occurrence, then either:

(a) the occurrence would probably not have occurred; or

(b) the adverse consequences associated with the occurrence would probably not have occurred or have been as serious, or

(c) another contributing factor would probably not have occurred or existed.

Other factors that increased risk: a safety factor identified during an occurrence investigation, which did not meet the definition of contributing factor but was still considered to be important to communicate in an investigation report in the interest of improved transport safety.

Other findings: any finding, other than that associated with safety factors, considered important to include in an investigation report. Such findings may resolve ambiguity or controversy, describe possible scenarios or safety factors when firm safety factor findings were not able to be made, or note events or conditions which 'saved the day' or played an important role in reducing the risk associated with an occurrence.