



## **Spatial Disorientation Cited in EMS Loss-of-control Accident**

*The Australian Transport Safety Bureau says that circumstances of the Bell 407 accident ‘combined most of the risk factors known for many years to be associated with helicopter emergency medical services accidents,’ including the pilot’s inexperience with long overwater night flights and the prevailing dark-night conditions.*

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*FSF Editorial Staff*

The night of Oct. 17, 2003, a Bell 407 emergency medical services (EMS) helicopter struck the water in Hillsborough Channel off the coast of Queensland, Australia, while en route from a hospital in Mackay to pick up a patient from a medical clinic on Hamilton Island, 49 nautical miles (91 kilometers) to the northwest. The helicopter was destroyed, and all three crewmembers were killed (Figure 1, page 2).

The Australian Transport Safety Bureau (ATSB) said, in its final report, that a significant factor in the accident was that “the helicopter departed controlled flight during flight under night visual flight rules, resulting in impact with the water.”

The report said that investigators did not determine the cause of the departure from controlled flight but that the circumstances of the accident “were consistent with pilot disorientation and loss of control during flight in dark-night conditions.”

The pilot had an air transport pilot license (helicopter) and a commercial pilot license (helicopter) and had 2,570 flight hours, including 46 flight hours in type and 149 flight hours in night visual flight rules (VFR) conditions. He also had a nondirectional beacon (NDB) endorsement, a very-high-frequency omnidirectional radio (VOR) endorsement, and a Grade 1 and Grade 2 instructor (helicopter) single-engine rating.



He was endorsed in accordance with Australian Civil Aviation Orders (CAOs) to fly eight helicopter models, including Bell 206 and Bell 407 helicopters. His last aviation medical examination was completed Dec. 6, 2002; the report did not say what class medical certificate he held.

The report said that the pilot received his initial night VFR rating Feb. 18, 2000, and completed a night VFR rating and biennial flight review Aug. 11, 2003. His last night VFR flight before the accident flight was a 0.2-hour flight on Oct. 15, 2003. During the previous year, he had recorded 75.5 night VFR flight hours; his last recorded instrument flight was a night base check on April 3, 2003.

In a previous job, the pilot conducted marine pilot transfer flights; most of the flights were scheduled flights averaging 0.6 hour, and most were within sight of the coastline. When weather conditions were considered unsuitable, the operator used a boat instead of a helicopter to perform the transfers, and the operator had taught the pilot that, in the event of inadvertent flight into instrument meteorological conditions (IMC), he should conduct a 180-degree turn to fly the helicopter out of IMC.

The pilot was hired for the EMS position on July 31, 2003, and placed on probation; the probationary period was still in

effect when the accident occurred. From Aug. 1–11, 2003, he received training from the operator’s check and training pilot. The training included area familiarization, use of a high-powered searchlight, night VFR flight and type endorsements on the Bell 206L and Bell 407 helicopters.

“The training pilot did not note any concerns with the pilot’s skills,” the report said.

Training records did not indicate that the pilot had received instrument training, although several training sessions “may have included some degree of instrument training,” the report said.

When the training period was over, the instructor filed a night VFR rating application form to certify that the pilot had completed a night VFR rating test, “and that the pilot had passed the test in all respects,” the report said.

“The night VFR rating application form did not include the requirements for practicing limited panel instrument flying, nor was there a requirement to do so. There was no annotation in any of the company training notes or in the pilot’s logbook to

the effect that any instrument flying had been conducted during the night VFR rating assessment.”

Completion of the night VFR rating test satisfied night VFR recency requirements of the CAOs and the operator. While working for the operator, the pilot accumulated an average of 4.8 night VFR flight hours each month in both Bell 407 and Bell 206L-3 helicopters.

The night of the accident, the pilot had been on standby duty at the base for 14.5 hours before the flight. His last day off had been Oct. 11.

## Helicopter Not Equipped for IMC

The accident helicopter was manufactured in Canada in 1997 and was imported into Australia in 2000 from Papua New Guinea. The airframe had 2,211 flight hours, and the engine had 1,253 flight hours since overhaul. The helicopter had been flown 17.8 hours since its most recent 300-hour phase inspection. The operator had complied with all relevant airworthiness directives and service bulletins.

### Planned Route From Mackay to Hamilton Island, Queensland, Australia

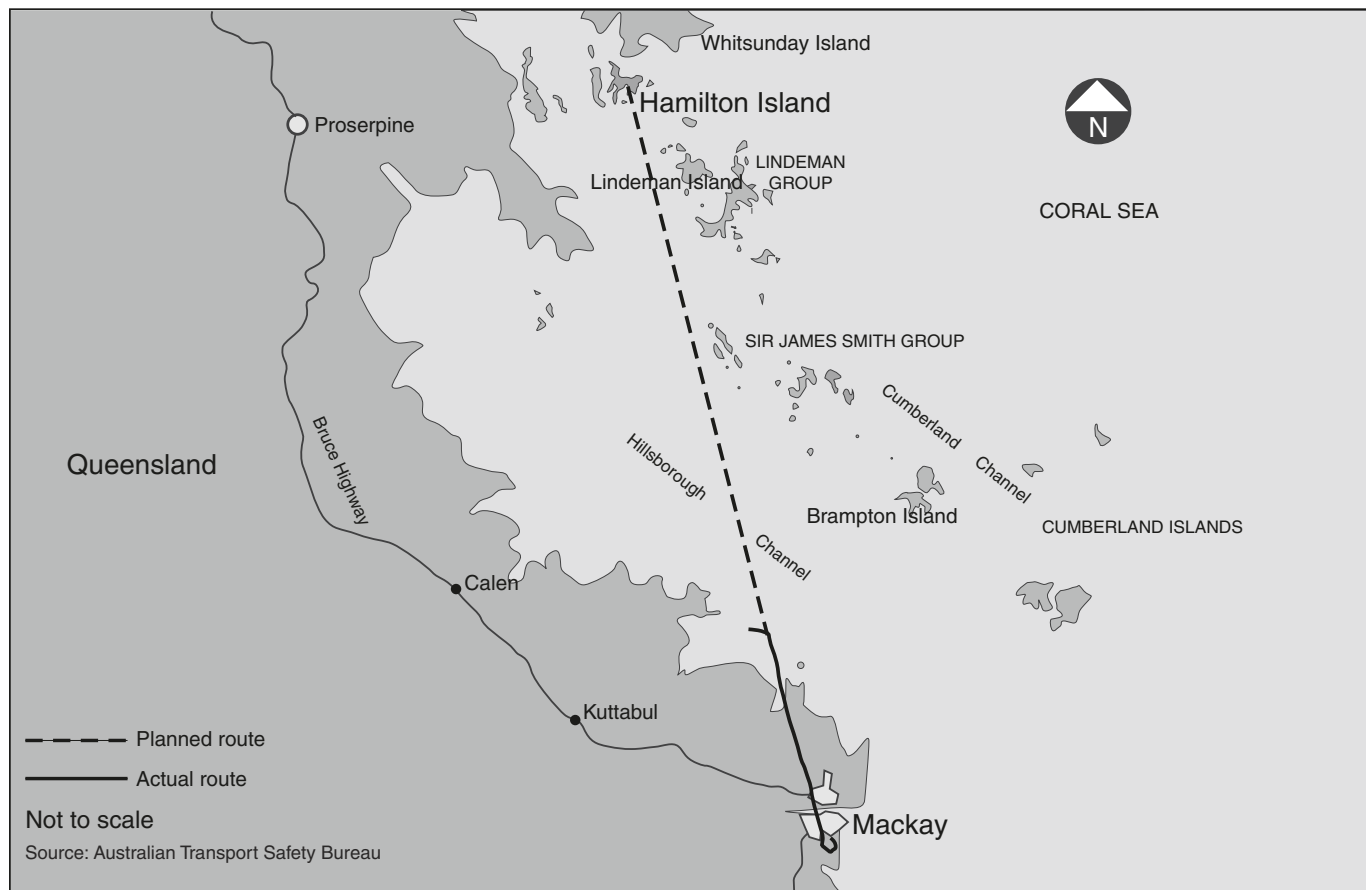


Figure 1

The helicopter was equipped for night VFR flight but not for flight in IMC.

The helicopter had been damaged substantially in an emergency landing accident in Papua New Guinea on April 11, 1999, and had been repaired.

The maintenance technician at the operator's base said that the pilot had called him at home the night of the accident to report a problem with the main transmission oil-pressure indicator. The technician said that the problem probably involved a faulty light and told the pilot to reseal a connector and then call back to confirm that the problem had been resolved. The pilot did not call before or during the flight.

The helicopter was operated by Canadian Helicopters Corp. (CHC) Australia, under contract to the Central Queensland Helicopter Rescue Service (CQRESQ). The Queensland Department of Emergency Services had oversight responsibilities.

### **Weather Forecast Predicted Isolated Thunderstorms**

The pilot obtained a weather briefing at 1742 local time, three hours and 40 minutes before the accident flight. The weather briefing called for isolated thunderstorms and scattered showers; scattered areas of smoke below 7,000 feet; isolated cumulonimbus clouds from 5,000 feet to 30,000 feet, broken stratus at 2,000 feet to 3,000 feet with precipitation (mainly over land), scattered cumulus at 2,000 feet to 8,000 feet over the sea and coast; and visibility of 2,000 meters (about one statute mile) in thunderstorms/rain, 4,000 meters (about 2.5 miles) in showers/rain, seven kilometers (four statute miles) in smoke and 2,000 meters in thick smoke. (In areas not experiencing thunderstorms, showers or smoke, visibility was greater than 10 kilometers [six statute miles].)

Subsequent forecasts (not obtained by the pilot) included no revisions.

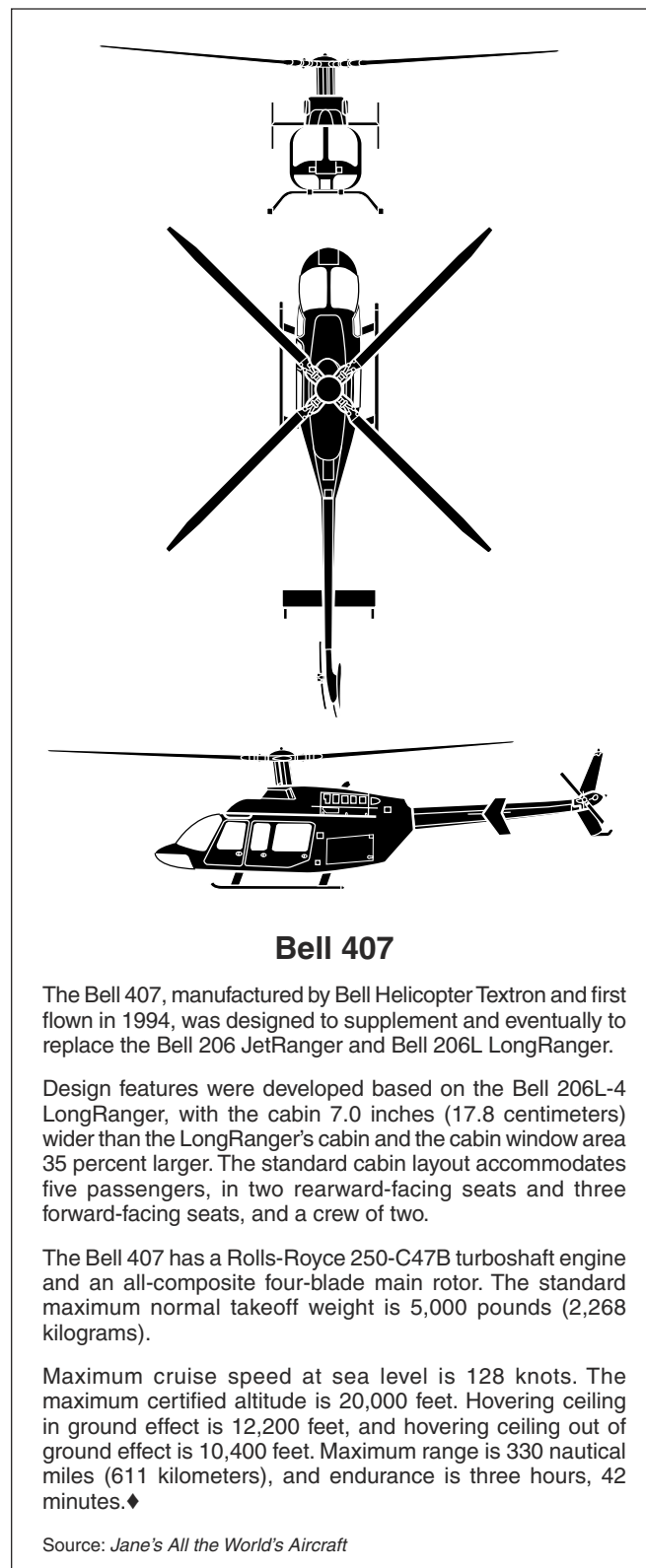
Weather observations at Mackay Airport at 2130 included unlimited visibility with scattered clouds at 2,900 feet and 7,300 feet and broken clouds at 9,800 feet.

The terminal area forecast for Hamilton Island at 1737 included unlimited visibility and scattered clouds at 2,500 feet.

Pilots at the operator's Mackay base said that they sometimes accessed the Bureau of Meteorology Internet site, which displayed precipitation imagery and the time at which the image had become available. The pilots said that, at the time of the accident, they were unaware that the Mackay weather radar site had regularly scheduled outages that occurred up to four times a day; during the outages, the image displayed on the Internet site was the last radar image before the outage. The night of the accident, an outage occurred from 2050 until

2250. There was no indication whether the accident pilot had accessed the Internet site before the flight.

On the night of the accident, the sun set at 1807; the moon set at 1005 and did not rise until 0006 and therefore was not illuminating the horizon during the flight.



NDB and VOR navigation aids were located at the airports at Mackay and Hamilton Island. The helicopter was equipped with a global positioning system (GPS) navigational moving map display, and the pilot was qualified to use it. Investigators determined that in the time period before the accident, the GPS system satellites were functioning normally, the report said.

Analysis of the pilot's radio transmission on the mandatory broadcast zone frequency indicated no anomalies. The pilot's two transmissions to the Queensland Department of Emergency Services Ambulance Service Communication Centre (ACC) also indicated no anomalies.

## **Pilot Estimated 30-minute Flight**

At 2103, the pilot was asked by ACC personnel about the feasibility of a flight from Mackay to Hamilton Island to pick up a patient who had been injured in a vehicular accident and to transport the patient to the Mackay Base Hospital. The pilot said that the flight was possible; at 2143, he conducted a takeoff from Mackay Airport with a paramedic and a crewmember (whose job was to assist in loading and unloading the patient and — when required — to operate the rescue hoist) on board.

“At 2137, the pilot contacted the ACC by radio and informed them that he was ‘on case,’” the report said. “Shortly thereafter, the pilot again contacted the ACC and announced that they had departed Mackay en route for Hamilton Island ... with an estimated time of arrival of 2207. ACC personnel acknowledged his report. No other communication was received from the helicopter crew for the remainder of the flight.”

About 2217, the people waiting on Hamilton Island for the helicopter telephoned the ACC to ask about its status.

“ACC personnel then made repeated unsuccessful attempts to contact the helicopter both by radio and by telephone to the on-board mobile phone,” the report said. “At 2239, ACC personnel contacted Australian Search and Rescue (AusSAR) and notified them that the helicopter was overdue.”

Pieces of wreckage were found soon after midnight about three nautical miles (six kilometers) southeast of Cape Hillsborough, about 15 nautical miles (28 kilometers) north northwest of Mackay.

Radar data indicated that the helicopter was flown to about 3,000 feet after departure from Mackay Airport at about 2135 on a 336-degree heading toward Hamilton Island. Altitude varied from 2,800 feet to 3,100 feet, and the helicopter remained on track until 2143:46.

The report said that radar data provided the following information about the remainder of the flight:

[The helicopter] commenced a left turn at a rate of approximately five degrees magnetic per second until the heading had changed through approximately 60 degrees magnetic. A track of approximately 299 degrees magnetic was then maintained for 25 seconds, with the altitude varying from 3,000 feet to 3,400 feet. At 2144:08, [the helicopter] climbed to approximately 3,439 feet and banked left towards the mainland, onto a heading of about 260 degrees magnetic ... then continued to climb through 3,500 feet until 2144:16, ... when it turned right to a heading of about 290 degrees magnetic. Following a climb to 3,839 feet, [the helicopter] turned right to 040 degrees magnetic ... and flew a heading of about 040 degrees magnetic for 12 seconds. At 2144:34, [the helicopter] turned right to a heading of 164 degrees magnetic and over the next 16 seconds, descended to 2,800 feet. At 2144:45 ... radar contact ... was lost. [The helicopter] was descending at the time.

Information from the helicopter's digital electronic engine monitoring unit, which recorded pressure altitude, indicated that, after recorded radar data ceased at 2144:46, the helicopter “initiated an extreme rate of descent, culminating in impact with the water.”

Examination of the wreckage indicated that the helicopter had struck the water at a high speed and in a nose-low attitude with the left skid low.

## **Pilot Experienced Anxiety During Similar Night Flight**

The report said that the pilot had conducted a previous patient-transfer flight from Mackay to Hamilton Island and back to Mackay on Sept. 3, 2003. Crewmembers on that flight said that similar dark-night conditions prevailed and that during departure from Hamilton Island, the pilot had asked twice if a crewmember could see the runway lights.

“It was reported that the pilot's voice was at a noticeably heightened level of anxiety during the event,” the report said. “Once the pilot had reacquired the island surface/ground-based lights, he was reported to ‘settle down’ somewhat, and the flight continued on track to Mackay uneventfully. The crew conducted an informal de-brief after the flight, during which the pilot was reported to have related that he ‘had lost reference [during the departure from Hamilton Island] and had to be comfortable again.’”

The report said that during the Sept. 3 event, the pilot had conducted a left turn “contrary to the published circuit direction,” that the turn was conducted “towards the high ground on the island” and that the turn “required him to look through/across the cockpit to reacquire the surface/ground-based lights of the island built-up area.”

## Clouds Were Below Lowest Safe Altitude

The *Aeronautical Information Publication* (AIP) of the Civil Aviation Safety Authority (CASA) of Australia says that for aircraft being operated under visual flight rules at or below 3,000 feet above mean sea level, or 1,000 feet above ground level — whichever is higher — flight visibility must be 5,000 meters (about three statute miles) and the aircraft must remain clear of clouds and “within sight of the ground or water.”

The AIP requires VFR pilots to “positively fix the aircraft’s position by visual reference to features shown on topographical charts at intervals not exceeding 30 minutes. When flying over the sea, visual reference features may include rocks and reefs and fixed manmade objects, which are marked on suitable charts and are readily identifiable from the air. Note: flight above more than [scattered] cloud, or over featureless land areas, or over the sea, may preclude visual position-fixing at the required intervals and may therefore make visual navigation impracticable.”<sup>1</sup>

The AIP also says that VFR flight may be conducted only if the pilot, when operating at or below 2,000 feet above ground level, “is able to navigate by visual reference to the ground or water.”

The helicopter flight manual, which included the company’s route information for the Bell 407 on the flight from Mackay to Hamilton Island, said that the lowest safe altitude (LSALT) was 3,000 feet. The report said, however, that when information from the CASA *VFR Flight Guide* was considered, the LSALT was calculated at 3,951 feet to 4,181 feet.

The report said, “The forecast cloud would therefore have been below that altitude and [would] have exceeded the CASA *VFR Flight Guide* 4/8 OKTAS limitation, indicating that flight at that altitude was not advisable. However, the pilot could have chosen to transit at a higher altitude.” (A designation of 4/8 OKTAS means that clouds obscure four-eighths of the sky; this is interpreted to mean “scattered” clouds.)

The Bell 407 *Aircraft Flight Manual* (AFM) did not discuss night VFR flight. The Bell 206 AFM said, “Night flight operation is limited to visual contact flight conditions. Orientation shall be maintained through visual reference to ground objects solely as a result of lights on the ground or adequate celestial illumination.”

The manufacturer said that night VFR flight requirements were not included in the AFM for the Bell 407 because the requirements were under the jurisdiction of local regulatory authorities; plans were to delete references to night VFR flight from future editions of the Bell 206 AFM.

The operator’s flight operations manual said that night VFR flight was permitted during search-and-rescue flights and EMS flights if the aircraft was equipped with a searchlight.

## Spatial Disorientation Risks Increase in Marginal Weather

Spatial disorientation accidents often involve VFR flight into IMC, the report said. The report cited a U.S. study that found that from 1994 through 2003, there were at least 83 airplane and helicopter accidents involving VFR flight into IMC. Of these, 83 percent of the pilots were not instrument-rated.<sup>2</sup>

The report said that a study of Australian EMS helicopter operations from 1992 to 2002 showed that there were three accidents; the accident rate was 4.38 per 100,000 flight hours. All three accidents occurred in Queensland and involved helicopters operated by local organizations known as Community Helicopter Providers (CHPs), which conducted about half of all EMS flights in Queensland, the report said.<sup>3</sup>

As part of the investigation, ATSB personnel conducted a night VFR flight intended to replicate as closely as possible the accident flight, including the dark-night conditions.

“There was no surface/ground-based lighting either left or right of the track, and only intermittent surface vessel lights were visible for reference,” the report said. “There was no celestial lighting, and the horizon was not visible when flying over the water to the northeast. Although the forecast weather conditions met the regulatory requirements for flight under the night VFR and the flight was conducted clear of cloud, maintaining a visual reference to the horizon was not possible.”

The crew of a Eurocopter BK 117 that was dispatched to search for the accident helicopter said that their flight had been conducted beneath clouds at 2,500 feet to 2,600 feet and that “it was a black, featureless night.”

## Clouds, Lack of Visible Horizon May Have Caused Disorientation

The report said that during the accident flight, the pilot might have become disoriented as a result of several factors, including:

- “Lack of a visible horizon due to the absence of celestial and surface/ground-based lighting;
- “Flight through cloud;
- “Flight through cloud with the [searchlight] illuminated; [or,]
- “Loss of primary flight instrument, such as the attitude indicator, requiring limited or partial panel flying.”

The report said that the circumstances of the accident “combined most of the classic risk factors known for many years to be associated with EMS helicopter accidents.” Major studies conducted in the United States in the 1980s examined those factors; although the studies’ results have been widely available, there were few indications that the organizations involved in this accident had incorporated “or in some cases, were even aware of, this significant work,” the report said.

The risk factors that were relevant to this accident include the following:

- The pilot’s relative inexperience, “particularly with regards to long distance, overwater night operations out of sight of land” and with the helicopter type; the pilot’s lack of an instrument rating; his newness to the organization and to EMS helicopter operations; and his status as a probationary employee;
- Factors in the operating environment, including the dark-night conditions without celestial lighting or surface/ground-based lighting, the flight path over water with few lighted features and the weather forecast of possible clouds at the altitude flown; and,
- Organizational factors, including the involvement of three different organizations in providing the service, the location of the operation at a base away from the operator’s main base and “actual or perceived pressures to not reject missions due to weather or other reasons.”

The report said that because three organizations were involved in providing the service, the organizational framework was “relatively complex” and “overall organizational safety oversight of the service was diffused.”

The report said that the Bell 407 had been authorized for use by CQRESQ management after a “third-party independent evaluation, which concluded that the Bell 407 was limited because of its lack of equipment necessary to permit instrument flight rules (IFR) flight and to mitigate the risk of night VFR flight. The decision was also apparently made with statistical evidence to indicate a high rate of mission cancellations because of the previous similarly equipped Bell 206 helicopter not being fully IFR capable. Cost may also have been a factor in this decision. Additionally, a fully IFR-equipped helicopter, which most likely would have been larger than the Bell 206 or 407, may have required an update to the current hospital helipad, with the associated costs.”

The contract between CHC Australia and CQRESQ said that the response time was to be 15 minutes for each emergency flight (or 30 minutes for an offshore emergency flight). This might not have been enough time for pilots to receive current weather information and assess conditions and celestial lighting before the flight, the report said.

The contract between CHC Australia and CQRESQ also cited specific contractual requirements for pilots. The accident pilot met all requirements except one; he had 2,345 flight hours — not the 3,000 flight hours specified. The report said that “his 149.4 [flight] hours [at night] and 12.0 hours instrument flying experience would not appear to constitute the ‘substantial’ night/instrument flying experience required as per the contract waiver clause. It would also not appear to satisfy the requirements of the service agreement, which required substantial aeromedical experience or more than 200 hours night flying experience for a pilot with that level of experience.”

CHC Australia, CQRESQ and the Department of Emergency Services Aviation Services Unit apparently were aware that the pilot’s experience did not meet their requirements, but “it appears that a good deal of emphasis was placed on the pilot’s previous marine pilot transfer experience as an acceptable alternative,” the report said.

When asked by ACC personnel about making the flight to Hamilton Island, the pilot immediately agreed to make the flight, “indicating that no extensive check of the latest weather forecast was undertaken,” the report said. Procedures required that if any flight was canceled, a report was to be filed indicating the reason for the cancellation; this requirement, along with the pilot’s probationary status, “may have placed unintentional additional pressure on the pilot to complete the flight,” the report said.

In addition, the accident pilot (and other pilots at the Mackay organization) might have been influenced by the knowledge that if an assignment was rejected, the assignment often was completed by an IFR-equipped helicopter operated by another rescue organization.

“It is possible that not being able to complete all tasks, even though for valid reasons, may have negatively impacted on the perception of the Mackay operation, the rescue organization and their relationship with the local community,” the report said.

## **ATSB Recommended Changes in Night VFR Requirements**

ATSB issued the following safety recommendations as a result of the investigation:

- “That [CASA] review the night visual flight requirements and promulgate information to pilots emphasizing the importance, during flight planning, of considering whether environmental conditions allow for aircraft orientation by visual reference alone, [whether] there is likely to be sufficient ground [lighting] or natural lighting and flight visibility along the proposed route to provide visual reference to the ground and/or water during the flight and [whether] they are capable of safely operating the aircraft should non-visual conditions be encountered.”

In response, CASA said that existing CAO requirements were adequate and that “it is the responsibility of the operators to ensure that pilots meet the requirements specified for rating issue, especially those related to instrument flying”;

- “That [CASA] assess the safety benefits of requiring a standby attitude indicator, with an independent power source, in all helicopters operating flights under the night VFR in the charter and aerial work category, excluding dual pilot training.”

In response, CASA said that a requirement for additional night VFR training would be “a more effective approach than introducing a mandatory requirement for the fitment of a secondary attitude reference instrument.” CASA had acted to “strengthen recurrent training and checking and operator proficiency checks for pilots undertaking [night VFR] flights” in helicopters being used in air transport operations, EMS, search and rescue and marine pilot transfer;

- “That [CASA] assess the safety benefits of requiring an autopilot or stability augmentation system in all single-pilot helicopter operating flights under the night VFR, in the charter and aerial work category, excluding dual pilot training.”

In response, CASA said that the introduction of Civil Aviation Safety Regulation Part 133 would address the recommendation. The regulation says, “For a night VFR flight by rotorcraft involving flight over water beyond a distance from land at which a coastline would be visible at night in VMC at 500 feet [above mean sea level] ... the operator must ensure that the rotorcraft is equipped with an approved automatic pilot, or is equipped with an approved automatic stabilization system, or carries a two-pilot crew”; and,

- “That [CASA] review its operator’s classification and/or its minimum safety standards required for helicopter [EMS] operations. This review should consider increasing the minimum pilot qualifications, experience and recency requirements; operational procedures; and minimum equipment for conduct of such operations at night.”

In response, CASA said that it would “review the requirements for helicopter EMS operators to include consideration for two pilots, or a stability augmentation and/or autopilot system; the special operational and environmental circumstances of helicopter EMS services, particularly with regard to pilot qualifications, training and recency, including instrument flight competency; and pilot recency requirements for helicopter EMS operations to ensure that operator check and training processes are focused on the EMS environment.”

After the accident, other organizations implemented the following actions:

- The operator adopted a number of changes in night VFR operational requirements, required Mackay base pilots to hold a command instrument rating and provided training for them to acquire and maintain the rating, and replaced the accident helicopter with an IFR twin-engine helicopter equipped with an autopilot;
- The Queensland Department of Emergency Services told all CHPs to comply with revised guidelines for night helicopter operations, including providing information for pilots on celestial lighting and allowing overwater operations at night only with adequate celestial lighting and a visual horizon. The department also said that it would take other actions, including the establishment of centralized clinical coordination of EMS aircraft operations and the strengthening of safety standards of generic service agreements with CHPs (including increased requirements for pilot recency and training);
- CASA said that it would develop competency standards for night VFR flight, including a requirement for a biennial flight review; consider requiring two-pilot crews on night helicopter EMS flights and issue civil aviation advisory publications on safety guidelines for helicopter EMS operations and night VFR operations; and,
- ATSB said that it would distribute copies of the accident report to all Australian organizations involved in helicopter EMS operations and would bring the report to the attention of the Australian Health Ministers Advisory Council for consideration in the development of standards and recommended practices in all aspects of EMS operations.♦

[FSF editorial note: This article, except where specifically noted, is based on the Australian Transport Safety Bureau Aviation Safety Investigation 200304282, *Bell 407, VH-HTD, Cape Hillsborough, Qld, 17 October 2003*. The 92-page report contains illustrations and appendixes.]

## Notes

1. The accident report cited the following: Civil Aviation Safety Authority of Australia. *Aeronautical Information Publication ENR (Route)*, Section 1, “General Rules and Procedures,” paragraph 19.2, “Flight Under the VFR.”
2. The accident report cited the following: Aircraft Owners and Pilots Association Air Safety Foundation. *Spatial Disorientation: Confusion That Kills*, Safety Advisory Physiology No. 1: 2004. Frederick, Maryland, U.S.
3. The accident report cited the following: Holland, J.; Cooksley, D.G. “Safety of Helicopter Aeromedical Transport in Australia: A Retrospective Study.” *Medical Journal of Australia* Volume 182 (2005): 17–19.



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