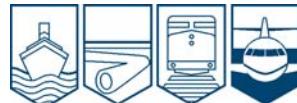




AVIATION INVESTIGATION REPORT

A04W0200



NAVIGATION DEVIATION

GOVERNMENT OF CANADA
DEPARTMENT OF TRANSPORT
BEECH KING AIR C90A C-FGXH
EDMONTON, ALBERTA
10 SEPTEMBER 2004

Canada

The Transportation Safety Board of Canada (TSB) investigated this occurrence for the purpose of advancing transportation safety. It is not the function of the Board to assign fault or determine civil or criminal liability.

Aviation Investigation Report

Navigation Deviation

Government of Canada
Department of Transport
Beech King Air C90A C-FGXH
Edmonton, Alberta
10 September 2004

Report Number A04W0200

Summary

The Transport Canada Beech King Air C90A (registration C-FGXH, serial number LJ-1162) was en route to the Edmonton City Centre Airport (Blatchford Field-CYXD) from Winnipeg, Manitoba, via Regina, Saskatchewan, under instrument flight rules. After descending into the Edmonton terminal control area in instrument meteorological conditions, the aircraft was vectored for a straight-in LOC(BC)/DME RWY 16 approach. Shortly after intercepting the localizer near the LEFAT intermediate fix, the aircraft descended about 400 feet below the minimum step-down altitude, and deviated 69° to the left of the final approach course. The crew conducted a missed approach eight nautical miles from the airport. During the missed approach, the airspeed decreased from 130 to 90 knots indicated airspeed, and the aircraft climbed above three successive altitudes assigned by air traffic control. The aircraft also deviated 43° from its assigned heading while being vectored to rejoin the localizer for Runway 16. Upon intercepting the localizer for the second time, the aircraft turned to the right of the approach centreline and descended below the minimum step-down altitude. After the aircraft descended below the cloud base, the crew gained sight of the airport, continued the approach visually, and landed at 1617 mountain daylight time.

Other Factual Information

C-FGXH is owned and operated by the Aircraft Services Directorate (ASD) of Transport Canada (TC). The ASD headquarters are in Ottawa, Ontario. There are five regions of operation across the country, including Edmonton where the occurrence aircraft and crew were based. The ASD provides aircraft and services to the federal government and NAV CANADA, including training for pilots who fly ASD aircraft.

The 1600 mountain daylight time (MDT),¹ weather at CYXD was as follows: wind 110° Magnetic at six knots, overcast 1300 feet above ground level (agl), altimeter 30.14, remarks stratocumulus eight oktas.² Forecast upper winds were light and variable at 6000 feet above sea level (asl)³ for the period covering the occurrence.

The first officer (FO), who was the flying pilot for both legs of the flight from Winnipeg, was in the left seat. The captain was in the right seat. There were four passengers on board; three were experienced pilots, and two were current on the C90A. The flight crew did not consult the passengers about the operation of the aircraft during the flight.

Prior to descent, the crew briefed the expected LOC(BC)/DME RWY 16 instrument approach to CYXD. When the aircraft was 2.5 nautical miles (nm) from intercepting the localizer, the Edmonton terminal arrival controller vectored the flight to intercept the approach inbound course at the minimum sector vectoring altitude of 4100 feet, and cleared it for the approach. (See Appendix A, Figure 1.)

Upon intercepting the localizer at 8.8 nm from the threshold, the aircraft immediately turned off course to the left. The FO initiated a missed approach by disengaging the autopilot, increasing pitch attitude, and increasing power. Shortly afterward, the airspeed was observed to decrease to about 90 knots indicated air speed (KIAS) before recovering to 130 KIAS. The minimum C90A single engine control speed (Vmca) was 90 KIAS, and the balked landing initial climb speed was 101 KIAS. The FO did not refer to the flight director during the missed approach.

The ASD standard operating procedure (SOP) for missed approaches call for the flying pilot to press the go-around button, which disconnects the autopilot, and follow the flight director which would be commanding a climb attitude. After stabilizing the aircraft in a climb, the autopilot could be re-engaged, if desired.

After the missed approach, the crew completed an abbreviated briefing for the second LOC(BC)/DME RWY 16 approach. They did not change the avionics settings. The FO flew the aircraft manually. On air traffic control (ATC) vectors, the aircraft was positioned to intercept the final approach track 10.7 nm from the Runway 16 threshold. The aircraft did not establish on track, and gradually drifted west to a maximum of 0.7 nm right of the approach centreline.

¹ All times are mountain daylight time (Coordinated Universal Time minus six hours).

² Oktas are an expression of a fraction of sky cover, in terms of eighths.

³ Unless otherwise noted, all altitudes are above sea level (asl).

During the approach, the captain gave their position as 4.7 DME (distance measuring equipment) when the aircraft was actually 10 nm from the airport because he had read the global positioning system (GPS) display of the distance to the final approach fix instead of the DME display. Radar data indicated that the aircraft descended to about 3500 feet, or 800 feet below the minimum step-down altitude of 4300 feet, before descending below the cloud base. (See Appendix A, Figure 2.)

Since the installation of GPS, certified for instrument flight rules flight in TC aircraft, ASD pilots increasingly use GPS as a substitute for much of the distance information on conventional displays such as DME. There is a tendency to inadvertently focus attention on the GPS distance when the DME is the appropriate instrument to use.

Earlier in the day, at Regina, the crew had been cleared for a LOC (BC) or NDB RWY 31 (GPS) instrument approach, which they intended to fly using GPS information. Radar data, corroborated by crew and passengers, indicated that the aircraft overshot the final approach course centreline and descended parallel to it, about 1 nm to the west. After the aircraft descended below cloud at about 800 feet agl, the crew completed the approach visually and landed uneventfully. During the stop at Regina, the crew discussed the possibility of an autopilot malfunction.

C-FGXH was equipped with two Collins APS-65 flight director/autopilot computers. A Collins 2 tube EFIS-84 (electronic flight instrument system) had been installed on the left panel in July 2004. The right side contained electromechanical instruments, including a Collins ADI 77 attitude indicator and an HSI 85 directional indicator.

For a back course approach, the procedure, as published in the *C90A Pilot's Operating Handbook*, is to set the course selector to the reciprocal of the inbound course. This ensures that the horizontal situation indicator (HSI) provides a "fly toward the needle" orientation, which is consistent with most instrument flying. This principle applies to conventional instruments as well as to the Collins EFIS. The *ASD Pilot Guide for the Beechcraft C90A* stated that, "If a localizer frequency is tuned, ... and the selected course is more than 105° from the lubber line, the annunciation B/C appears to the right of the lubber line. When B/C is annunciated, the course deviation automatically reverses to provide the correct left/right deviation for back course approaches".

While on descent into the Edmonton area, the crew began setting the appropriate navigation equipment for the approach. They tuned the localizer frequency, and set the course selector on the left-side electronic HSI (EHSI) display to 343° M. The aircraft heading at the time was 271° M, and the B/C annunciator was not illuminated since the heading was within 105° of the course selection. When the crew turned the course selector to 163°, the B/C annunciator illuminated, and the course selector was left at 163°. The HSI track bar indication on the back

Collins FCS-65 Autopilot Modes

"APPR" (Approach)

- intercepts and tracks front course LOC
- requires course selector to front course
- vertical guidance available

"B/C" (Back course)

- intercepts and tracks back course LOC
- requires course selector to front course
- no vertical guidance

"NAV" (Navigation)

- intercepts and tracks selected track
- no vertical guidance

"HDG" (Heading)

- maintains pilot-selected heading
- no track intercept
- no vertical guidance

course approach would be reversed and, to intercept the desired track, it would be necessary for the pilot to turn the aircraft away from the course needle instead of toward it. The captain had set his HSI course selector to 343°.

The captain had 17 years experience and 580 hours on the Beech King Air series, with 64 hours in the preceding year. His most recent recurrent training and instrument flight check/pilot proficiency check (IFC/PPC) was completed on a C90A simulator in May 2004. The FO had seven years experience and 180 hours on the Beech King Air series, with 19 hours in the preceding year. His most recent recurrent training and IFC/PPC on type was completed on a simulator in March 2004. His qualification on the C90A was limited to FO duties. Both pilots had practised back course approaches in their latest C90A simulator training. The simulator used was equipped with EFIS instrumentation similar to that in C-FGXH.

Both pilots attended EFIS transition training, conducted by ASD personnel. This training, completed in August 2004, consisted of 1.5 hours ground school and one hour of flight indoctrination. The incident occurred on their fourth operational trip following the training. The incident pilots, and other ASD pilots, indicated that the EFIS transition training did not fully address some pertinent operational details of the EFIS.

The *ASD Fixed-wing Flight Operations Manual* states that pilots must accomplish two hours of flight training annually on a C90A aircraft, approximately six months after completing simulator training and the IFC/PPC. After the occurrence, an ASD audit determined that, in addition to findings related to operational control and flight following, 12 Edmonton-based pilots had not completed the stipulated training and required this training before further operational flying.

Psychologist Lisanne Bainbridge, in "*Ironies of Automation*,"⁴ and as quoted by James Reason,⁵ states that: "Skills need to be practised continuously in order to preserve them. Yet an automatic system that fails only very occasionally denies the human operator the opportunity to practice skills that will be called upon in an emergency. Thus, operators can become de-skilled in just those abilities..." Pilots flying ASD aircraft were generally encouraged to use the automated flight features of the C90A as much as possible, and manually flying the C90A was not encouraged in operations. During the FO's and captain's simulator training and IFC/PPC sessions, manual flying abilities were trained and tested, primarily on missed approach procedures.

Post-incident ground inspection and flight testing of navigation systems in C-FGXH did not reveal any malfunctions. The flight testing consisted of several LOC/(BC)/DME RWY 16 approaches at CYXD, during which the avionics systems were set to various configurations. Normal intercept and localizer tracking was accomplished with the course selector set to 343° and the flight director set to B/C. With the course selector set to 163° and the flight director to B/C or to APPR, aircraft tracking was similar to that of the first approach of the incident flight. The second incident approach track was duplicated by setting the course selector to 163° and

⁴ Bainbridge, L., "Ironies of Automation" in J. Rasmussen, K. Duncan and J. Leplat (eds.), *New Technology and Human Error*, (Chichester: Wiley, 1987), pp. 271-83.

⁵ Reason, J., *Managing the Risks of Organizational Accidents*. (Brookfield, VT: Ashgate Publishing, 1997).

manually flying toward the reverse-sensing HSI track bar. The EFIS and autopilot manufacturer confirmed these flight behaviours through data analysis and simulation.

NAV CANADA monitoring and maintenance records indicated there were no known outages or anomalies of navigation aids associated with the approach flown at the time of the incident.

Analysis

All aircraft and ground based systems were shown to have operated correctly during the occurrence. The analysis will focus on the crew inputs and crew knowledge of the aircraft systems.

It is likely that the approach at Regina was conducted with the flight director in heading mode. This resulted in the aircraft flying parallel to, and offset from, the desired track. After completing that leg, the crew was under the impression that they may have had a problem with the autopilot, and the significant course deviation on the first approach at CYXD reinforced that belief.

During preparations for the first approach at Edmonton, the crew initially set the EHSI course selector to 343° M, a heading appropriate for the back course approach to Runway 16. They expected a B/C annunciation on the EHSI, which they believed would signify that they had correctly set the course selector for the back course. When this indication did not appear, they changed the course setting to 163° M, which caused the light to illuminate. On turning left, past a heading of 268° M during the localizer intercept, the B/C annunciator would have extinguished; however, with their focus on the approach, the crew did not notice this event. Because of their unfamiliarity with the recently installed EFIS equipment, they conducted the approaches at CYXD with the course selector set to an incorrect track.

Flight director/autopilot behaviour on flight and ground testing of C-FGXH after the occurrence, as well as data from the autopilot manufacturer, confirmed that upon intercepting the approach centreline on the first approach, the crew likely had the course selector on the left-side EHSI set to the inbound course of 163° rather than the required 343°. As a result, the flight director/autopilot would have initiated a turn to orient the aircraft toward the track appropriate for a front course localizer approach.

On initiating the missed approach, the FO disengaged the autopilot and manually flew the aircraft without reference to the flight director. The significant speed, altitude, and heading deviations on the missed approach indicated that the FO was unable to transition to effective manual control. Using the flight director in the “go around” mode in the initial phase of the missed approach, in accordance with the SOP, followed by re-connection of the autopilot, would probably have reduced the flying pilot’s workload and helped to ensure more stable flight while receiving vectors for the second approach. Airspeed deterioration to V_{mca}, which was below the balked landing speed of 101 KIAS, could have resulted in seriously reduced performance and control difficulties in the event of an engine failure.

During the missed approach, while manoeuvring for the second approach, the FO had difficulty controlling the aircraft. It is possible that the FO's manual flying skills in the C90A had degraded from reliance on the autopilot in operational flying. Although the FO was trained and tested, during training sessions and IFC/PPC rides, in manual flying during the initial stages of missed approach procedures, he was unable to maintain precise control while being vectored for the second approach.

After the missed approach, the crew initiated the second approach without a complete briefing to evaluate the aircraft systems set-up. Consequently, they did not detect the improper course selector setting, which remained unchanged for the second approach. The FO attempted to manually fly the intercept toward the reverse-sensing EHSI bar, which resulted in the aircraft drifting to the right of the approach centreline. The course selector on the captain's HSI was set properly for the back course and provided accurate navigation information. However, the discrepancy between the two displays was not resolved before the aircraft had descended below cloud, and the approach was continued under visual conditions.

The management of crew resources was not effective given that:

- The HSI and EHSI were set differently.
- The second approach was not fully briefed.
- The captain allowed the FO to continue the second approach with a significant deviation from the desired track.
- With the aircraft not performing as anticipated, none of the experienced flight crew in the cabin were consulted for trouble shooting.

The crew's dependence on GPS information resulted in their estimating their position as 4.5 nm closer to the airport than it actually was. The significant deviation from the approach centreline and the premature descent profile suggest that the crew did not have an accurate perception of their position in relation to the approach centreline or of their distance from the airport. Under the prevailing weather conditions, the aircraft would have been in cloud until it descended to about 1300 feet agl, and its margin of protection from obstacles would have been reduced.

The actions of the flight crew during these three instrument approaches indicate that they did not have a firm understanding of the flight director, autopilot, and recently installed EFIS. Their reduced effectiveness in setting up and flying the approaches can be attributed to a combination of limited recent flying time on type and insufficient aircraft systems knowledge. The EFIS transition training was not sufficient to ensure that the crew received adequate transference and confirmation of skills in using the new avionics. In addition, the ASD was generally unable to ensure that all pilot training requirements were fulfilled before dispatching pilots on operational flights.

Findings as to Causes and Contributing Factors

1. Because the flight crew did not have sufficient familiarity with the C90A EFIS equipment system's presentations and operation, they used improper EHSI course settings and flight director mode selection on three successive instrument approaches.

2. The inability of the crew to perform at the expected standard resulted from limited recent flying time and inadequate transition training in using the new avionics.
3. While flying a missed approach procedure, the flying pilot was unable to transition to effective manual control of the aircraft. As a result, the aircraft speed decreased significantly below a safe level, and the ATC-assigned altitudes and headings were not adhered to.
4. On the second approach at Edmonton, the crew focussed on the GPS distance reading from the final approach fix, instead of the DME display. This led to a premature descent, and the aircraft was operated below the minimum published step-down altitudes for the approach.
5. The crew's resource management in preparation for and during the three approaches was not sufficient to prevent the hazardous deviations from the required flight paths.

Finding as to Risk

1. The ASD did not encourage pilots to use manual flying skills in operational flying, thus creating the potential for manual flying skills degradation from non-use.

Other Finding

1. A post-incident audit revealed a number of examples of non-compliance with the *ASD Flight Operations Manual*, including a lack of appropriate pilot-training record keeping. Therefore, there was no assurance that pilots would receive required training within specified time frames.

Safety Action Taken

The ASD has corrected operational and training deficiencies that were revealed in a post-incident operations audit of the Edmonton base. Pilots who had not received the minimum flight training schedule mandated in the *Fixed Wing Operations Manual* were required to complete this training before their next operational flights. In addition, operational control of all flights was improved through a revised dispatch and flight-following system.

A Training Review Board convened by the ASD evaluated the performance of selected Edmonton-based pilots on the C90A. Consequently, some pilots were removed from flying duty on type.

An internal Safety Bulletin distributed to pilots flying ASD aircraft, addressed the following issues associated with this occurrence:

- errors in managing automatic flight systems;
- encouraging periodic autopilot disconnect to improve monitoring vigilance;
- flight director/autopilot management;
- flight path deviations induced by autopilot activation; and,
- timely pilot intervention to correct flight path deviations.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 19 October 2005.

Visit the Transportation Safety Board's Web site (www.tsb.gc.ca) for information about the Transportation Safety Board and its products and services. There you will also find links to other safety organizations and related sites.

Appendix A - C-FGXH Flight Path, LOC (BC) DME RWY 16 Approaches at CYXD

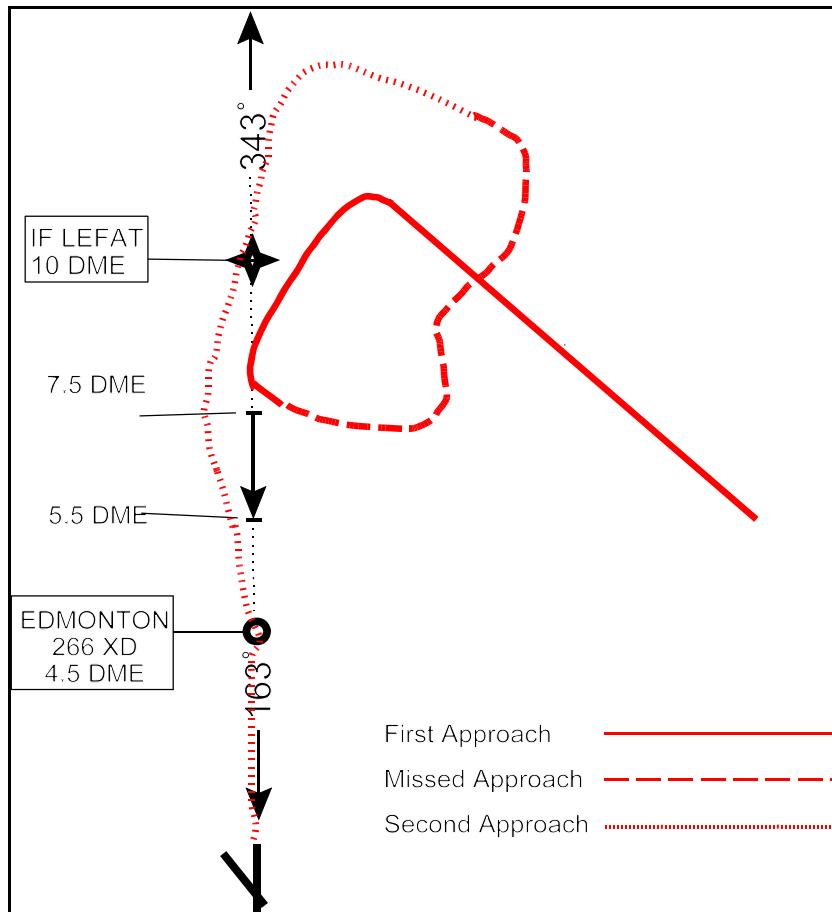


Figure 1. Plan view of approaches at CYXD

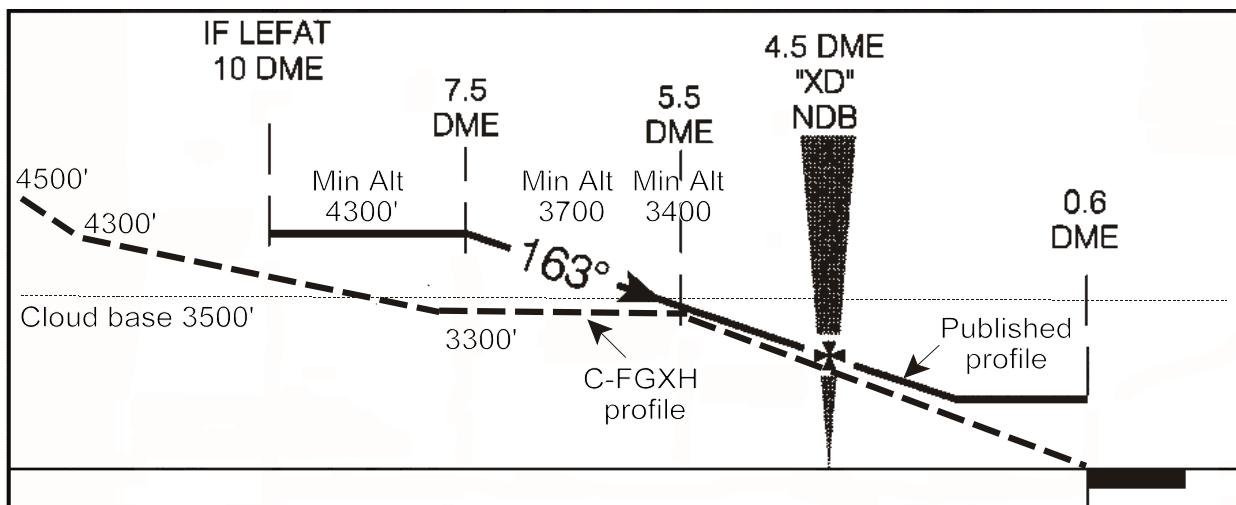


Figure 2. Profile view, second approach