

May 6, 2004

In Reply Please Refer  
To: 940-2004-05-133

Mr. Bob Gretz  
National Transportation Safety Board  
Northeast Regional Office  
2001 Route 46, Suite 504  
Parsippany, New Jersey 07054

Re: Beech Model 1900D, Serial Number UE-40, Registration Number N240CJ, accident in Yarmouth, Massachusetts, on August 26, 2003.

Dear Mr. Gretz:

Pursuant to the provisions of 49 CFR 845.27, Raytheon Aircraft Company (RAC) offers the following submission concerning the above-referenced accident.

On August 26, 2003, at 1540 EDT (all times listed in this narrative are Eastern Daylight Time), a Beech 1900D Airliner, operated by Colgan Air Inc. (d.b.a. US Airways Express), as flight 9446, was destroyed when it collided with water near Yarmouth, Massachusetts. The flight departed Barnstable Municipal Airport (HYA), Hyannis, Massachusetts, destined for Albany International Airport (ALB), Albany, New York. An instrument flight rules flight plan was filed for the repositioning flight conducted under 14 CFR Part 91. Visual meteorological conditions prevailed. The two crew members on board sustained fatal injuries. Following are RAC comments about the investigation.

## **1. Maintenance actions from August 23 – 26, 2003**

On August 23, 2003, a Detail Six phase inspection was started on the accident airplane at the Colgan Air Inc., facilities in Hyannis, Massachusetts. The phase inspection was interrupted, and the remaining work was postponed until August 24, 2003. Ten revenue flights took place, and the phase inspection continued on the evening of August 24, 2003.

As part of the phase inspection, a free play check of the elevator trim actuators was performed. Both actuators failed the inspection, requiring replacement of the actuators. Colgan Air Inc., mechanics replaced both Part Number 129-526033-3 elevator trim actuators with 129-526033-6 and -7 actuators. When the mechanic who removed and replaced the left trim actuator (Dominick Battaglia) was asked what procedure he used during the actuator replacement, he stated that he used Chapter 27-30-06 ELEVATOR TAB ACTUATORS – MAINTENANCE PRACTICES, ELEVATOR TRIM TAB ACTUATOR REMOVAL, in the Beech 1900D Airliner Maintenance Manual (hereinafter referred to as “maintenance manual”). Step c. in the procedure, requires the removal of the elevator, prior to removing the trim actuator. When asked, Battaglia stated that they did not follow that step, but chose to remove the actuators with the elevators still in place. He stated that that was how he was trained when removing and replacing elevator trim actuators. He said that after the actuator replacement was complete, the mechanics started a functional check of the system using the maintenance manual procedure. While moving the elevator trim wheel, it was noted that it began to bind and was difficult to turn. They determined that the forward elevator trim cable had become unwound from the forward elevator trim drum. At this point, Battaglia’s shift was over, and he left.

During the next day, Colgan Air Inc., representatives called RAC Airline Technical Support. Colgan called RAC with a question regarding the part numbers of the trim actuators they had changed the night before. The Beech 1900D Airliner Illustrated Parts Catalog did not allow the combination of actuators (-6 and -7) that had been installed. Colgan Air Inc., representatives then decided to replace the -6 actuator with a -9, which was called out in the illustrated parts catalog. During that same time period, the forward elevator trim cable drum was removed from the pedestal area. It was determined that the cable was kinked, and the decision was made to replace the cable with a new one. That night, Battaglia was tasked with replacing the right elevator trim actuator with the -9 actuator.

That same night (Monday night), two mechanics (Dan Kinan and Scott Servis) were tasked with removing and replacing the forward elevator trim cable. They stated during their interviews that the cable change took place without any problems being encountered. When asked what procedure was used for removing and replacing the cable, they stated that they used Chapter 27-30-04 ELEVATOR TAB CABLES – MAINTENANCE PRACTICES in the maintenance manual. They also stated that they used Figure 201 of Chapter 27-30-04 for guidance on how to wrap the forward elevator trim drum.

During the interviews with the two mechanics, it was noted that the mechanics chose to skip or omit several steps in the maintenance manual procedure. Step g. of Chapter 27-30-04 ELEVATOR TRIM CABLE REMOVAL states, “Attach lead lines to the aft ends of the forward cables and properly identify them to facilitate reinstallation.” The mechanics stated that they felt that this step was not necessary. They chose instead to mark pulley brackets with a “T” (beginning with the third pulley aft) to keep track of which pulley the left hand threaded cable should go through. They did not mark the cable end with a “T”, as they felt that they were just going to immediately install the other cable (within 15 minutes) and felt it was not necessary. During examination of the accident airplane wreckage, investigators located 2 of the 6 pulley brackets installed in the forward trim cable run. One of the two exhibited a hand-written “T”. The mechanics then used the removed cable as a guide to mark the center location and the FDR bridle location. According to the NTSB Airworthiness Group Chairman’s Factual Report Of Investigation, Appendix B, Servis said that they oriented the trim cable drum as depicted in Figure 201 (with the keyed side facing the mechanic), and wrapped the cables using Figure 201 as a guide. The mechanics then installed the new cable. When asked if any part of the procedure was confusing, they stated that it was not, and that everything went smoothly. Following the cable installation, one mechanic (Servis) went home. The other mechanic stayed to finish rigging the trim system after the actuator change was completed.

The cable installation procedure in the maintenance manual instructs the mechanic to rig the cables per Chapter 27-30-05 ELEVATOR TAB CONTROL RIGGING – MAINTENANCE PRACTICES. Both the cable installation procedure and the rigging procedure instruct the mechanic that it may be necessary to re-index the manual trim wheel to 0, when the elevator trim tabs are in neutral. Kinan stated that the wheel was re-indexed to 0. Step f. of the elevator tab rigging procedure instructs the mechanic to, “Using a travel board (6, Chart 1, 27-00-00), adjust the elevator trim tab for a deflection of  $5\ 1/2^\circ + 1/2^\circ - 0$  up from neutral and  $16\ 1/2^\circ + 1^\circ - 0$  down from neutral with the cable stops in the aft fuselage section.” Kinan stated that they used a digital protractor for this procedure and not a travel board as instructed. The maintenance manual offers no provisions for using a digital protractor for this procedure and offers no guidance on their use. The mechanic said that they checked the travel on the trim tabs by having one mechanic to operate the manual trim wheel in the cockpit with another mechanic on a lift reporting the readings from the digital protractor on the trim tabs. In addition, the mechanic stated that they operated the elevator trim system from stop to stop several times, using both the manual trim wheel and electric trim servo, with no discrepancies noted.

## 2. Maintenance Manual

During a component examination of the accident airplane pedestal at NTSB headquarters in Washington D.C., on September 4, and 5, 2003, it was noted that Figure 201 of Chapter 27-30-04 contained an error. The illustration depicted the keyed side of the elevator trim drum along side an arrow indicating “forward as installed.” The illustration should have shown the flat side of the trim drum based on that orientation of forward as installed. The depiction of the keyed side of the drum was the sole portion of the trim control forward cable installation procedure that was in error. As a result, Raytheon Aircraft Company released Temporary Revision (TR) 27-9 Dated September 12, 2003, to add a “Manual Elevator Trim Operational Check” and TR 27-10, Dated October 22, 2003, which revised Chapter 27-30-04, ELEVATOR TRIM TAB CABLE INSTALLATION, and also included a revised illustration of the forward elevator trim drum, in the Model 1900D Airliner Maintenance Manual. Raytheon Aircraft Company released Safety Communiqué 234 on September 24, 2003, which advised operators to perform an operational check of the manual trim system per TR 27-9. Raytheon Aircraft Company did not receive any comments from operators concerning any problems found. The FAA issued Airworthiness Directive 2003-20-10, effective on October 15, 2003, which required operators to perform the manual elevator trim check specified in TR 27-9, and provided a change to Figure 201 in the maintenance manual.

The Part Number 129-590000-15 1900D Airliner Maintenance Manual at the time of the accident contained the following warning in Chapter 20-00-00 STANDARD PRACTICES – AIRFRAME:

**“WARNING: AFTER RECONNECTION OF ANY COMPONENT, REMOVE ALL IDENTIFICATION TAGS. CHECK ALL ASSOCIATED SYSTEMS FOR CORRECT FUNCTION PRIOR TO RETURNING THE AIRPLANE TO SERVICE.”**

Chapter 27-30-09 ELEVATOR TRIM OPERATIONAL CHECK, in effect at the time of the accident, presented specific procedures to accomplish the required check.

Notwithstanding the maintenance manual requirements, 14 CFR 43.13 (b) states:

“Each person maintaining or altering, or performing preventive maintenance, shall do that work in such a manner and use materials of such a quality, that the condition of the aircraft, airframe, aircraft engine, propeller, or appliance worked on will be at least equal to its original or properly altered condition (with regard to aerodynamic function, structural strength, resistance to vibration and deterioration, and other qualities affecting airworthiness).”

Compliance with this regulation requires functional checks in order to assure that the aircraft “will be at least equal to its original or properly altered condition.”

Beyond the requirements of the maintenance manual and regulations, functional testing is a matter of basic training for airframe mechanics. AC 65-15A, Airframe and Powerplant Mechanics Airframe Handbook, states (beginning at page 75 of Chapter 2, Assembly and Rigging, subparagraph Adjustment of Control Surfaces):

“In order for a control system to function properly, it must be correctly adjusted... Rigging any system requires that the step-by-step procedures be followed as outlined in the aircraft maintenance manual... The range of movement of the controls and control surfaces should be checked in both directions from neutral... After a system has been adjusted, the full and synchronized movement of the controls should be checked. When checking the range of movement of the control surface, the controls must be operated

from the cockpit and not by moving the control surfaces. During the checking of control surface travel, ensure that chains, cables, etc., have not reached the limit of their travel when the controls are against their respective stops... Trim tabs and other tabs should be checked in a manner similar to the main control surfaces. The tab position indicator must be checked to see that it functions correctly.”

### **3. Flight Crew**

The flight crew was current and qualified in the Beech 1900D in accordance with Colgan Air Inc., and FAA requirements. The crew had finished their duty day (10.6 hours for the pilot and 10.7 hours for the copilot), and were headed home. The crew was called and asked to take the accident airplane on the repositioning flight to ALB (after another crew had turned down the trip). The crew agreed and traveled back to the airport.

The Colgan Air Inc., Beech 1900 Company Flight Manual stated the following:

"A preflight inspection will be accomplished prior to every flight. A comprehensive 'Preflight Inspection - Detailed' must be accomplished on the aircraft's first flight of the day, after significant maintenance has been performed or anytime the aircraft's condition is in question."

Beech 1900D Airliner FAA Approved Flight Manual, Part Number 129-590000-3E, Section IV – Normal Procedures, provides first flight of the day preflight checks of the elevator trim system. On page 4-3, COCKPIT, step 3 states, “Elevator Trim.....SET 1 ½ UNITS NOSE UP.” On page 4-6, TAIL SECTION, step 5 states, “Elevator, Elevator Tab, and Static Wicks (4).....CHECK. VERIFY TABS ARE IN NEUTRAL POSITION.” After this step the following note is listed.

#### **NOTE**

The elevator trim tab neutral position is determined by observing that the trailing edge of the elevator trim tab aligns with the trailing edge of the elevator, when the elevator is resting against the downstops with the elevator trim wheel set 1 ½ units up.

If the forward trim cable had been mis-installed as described in the NTSB Airworthiness Group Factual Report, and the first flight of the day preflight check was properly done, the crew should have noticed the incorrect elevator trim tab position.

The Colgan Air Inc., Beech 1900 Company Flight Manual also stated the following concerning interruptions of the checklists.

"Interruptions to checklists increase the possibility of items being missed, which in turn may create hazards to flight operations. When interruptions occur, the crew must give consideration to restarting the checklist from the beginning, taking into consideration such factors as the length and type of interruption."

According to CVR transcripts, the checklist flow was interrupted on several occasions. The flight crew did not restart, or discuss restarting, any checklists after the interruptions. During the Taxi checklist, the copilot stated, “...three trims are set,” and the pilot replies “roger.” No other mention of the airplane trim systems was noted on the CVR prior to this comment, or before takeoff.

Approximately 38 seconds after the takeoff roll is initiated, the captain comments, “we got a hot trim...” 2 seconds later the pilot states, “kill the trim kill the trim kill the trim.” 2 seconds after that the pilot said, “roll

back roll back...roll it back roll my trim..." The Beech 1900D Airliner FAA Approved Flight Manual, Section III – EMERGENCY PROCEDURES contains the following information.

## **FLIGHT CONTROLS**

### **UNSCHEDULED ELECTRIC ELEVATOR TRIM (if installed)**

- 1. Airplane Attitude.....Maintain (using elevator control)**
- 2. Control Wheel Disconnect Switch.....Depress Fully (Pitch Trim OFF Annunciator - ILLUMINATED)**

#### Note

Autopilot will disengage and Rudder Boost will be interrupted when the disconnect switch is depressed

3. Manually retrim airplane.
4. Elevator Trim Switch (pedestal).....OFF (PITCH TRIM OFF Annunciator EXTINGUISHED)

It should be noted that the electric trim system can be disconnected in any of four ways: By depressing the trim disconnect switch located on each control wheel, moving the ELEV TRIM (ON) – OFF switch located on the pedestal to the OFF position, by pulling the ELEV TRIM circuit breaker on the right side panel, or by moving the ganged BAT, L GEN, and R GEN switches to OFF. In addition, any elevator trim servo movement can easily be overcome by manual inputs by the pilot, using the cockpit trim wheel.

Approximately 41 seconds after the takeoff roll is initiated, the pilot states, "pull the breaker..." The copilot responds, "where is it?" The pilot then says, "look left of the silver thing..." It is possible that the pilot was referring to the ELEV TRIM (ON) – OFF switch located in the pedestal, left of the silver PARKING BRAKE handle.

The pilot commanded the copilot to, "roll it back...roll my trim..." FDR data indicated that the elevator trim traveled only in the airplane nose down direction after takeoff. It is not known whether the crew tried to use the electric trim system. Recovered components of the electric trim system did not reveal any discrepancies that would have precluded its normal operation.

## **4. Tests and research**

On October 14, 2003, the NTSB Airworthiness Group convened at Raytheon Aircraft Services in Wichita, Kansas, for an elevator trim system evaluation. This evaluation revealed that it was possible to incorrectly wrap the forward trim drum, but several steps in the maintenance manual procedure have to be omitted or misinterpreted. It was determined that it is not possible to install the trim drum as illustrated in Figure 201. In order for the mechanic to install the drum and cause a reversal of control at the manual trim wheel, he would have to ignore the portions of the illustration that depict the "forward as installed" arrow and the orientation of the terminal ends coming off of the drum when installed. The cables would then need to be crossed once along the cable run to facilitate connecting of the turnbuckles after failing to use the lead lines as specified in the maintenance manual. It should also be noted that this illustration has been in the Model 1900 series Maintenance Manuals since 1984, with no prior report of problems.

After the crossed cables were connected, with the trim drum mis-wrapped, it was confirmed that the elevator trim tabs moved opposite of the direction commanded at the trim wheel. It was also verified that electric trim

inputs continued to operate normally. The manual trim wheel was then re-indexed per the procedure in the maintenance manual. The mis-trim demonstration then revealed that when the manual trim wheel was rotated in the nose-down direction, the trim indicator moved well past the "6 DOWN" limit, resulting in no markings being visible on the trim indicator when the stop was reached. At this point, the trim tabs were in the full airplane nose up position. It was then noted that when the manual trim wheel was moved toward the nose-up direction, the trim indicator did not reach the "10 UP" limit, but stopped with approximately 3 units of nose up trim indicated when the stop was reached. At this point the trim tabs were in the full airplane nose down position.

According to the expanded procedures for the TAXI CHECKLIST, of the Colgan Air Inc., Beech 1900 Company Flight Manual, the captain is instructed to, "verify proper trim indicator positions (UP 2 Units UC & 3 Units UE, Roll 0, Yaw 0) and state 'SET'." The procedures also instructed the copilot to complete the same task. Based on the mis-rigging demonstration, if the trim drum was mis-wrapped and the manual trim wheel was re-indexed per the Beech 1900D Airliner Maintenance Manual, and the pilot placed the indicator on 3 units of nose up trim prior to takeoff, they would have begun the takeoff roll with the elevator trim tabs in the full airplane nose down position. This is not reflected in the FDR information, which indicated that the airplane began the takeoff roll with 2° of airplane nose down trim. This indicates that if the forward cable was improperly installed as described above, the manual trim wheel was not re-indexed per the maintenance manual as stated by the mechanic.

The typical takeoff trim setting used by Colgan Air Inc. corresponds to approximately 4° of UP trim (tab down). A NTSB Performance Study revealed that during the takeoff roll, the elevator did not leave the trailing edge down stop as soon, and did not move in the trailing edge up direction as rapidly, as during previous takeoffs. This study indicates that the elevator trim tab was not deflected into the airstream as much as it had been in the previous takeoffs, confirming that the trim was mis-rigged.

## **5. RAC Proposed Findings**

As a result of the investigation of the subject accident, RAC proposes the following findings:

- A. During the maintenance activity from August 23 – 26, 2003, the maintenance technicians did not follow the required steps for removing and replacing the elevator trim actuators and forward elevator trim cable, as outlined in the maintenance manual.
- B. FDR information indicates that the elevator trim tabs moved to the full airplane nose down position after takeoff.
- C. CVR information indicates that the flight crew was experiencing pitch control problems.
- D. Exemplar testing of another Model 1900D revealed that the depiction of the keyed side of the drum was the sole portion of the trim control forward cable installation procedure that was in error.
- E. It was not possible to install the trim drum as depicted in Figure 201, due to the arrow indicating "forward as installed."
- F. It was not possible for that depiction, in and of itself, to have resulted in reversal of the elevator trim tab control system.
- G. Exemplar testing of another Model 1900D revealed that the required rigging checks that were contained in Chapter 27-30-05 of the 1900D maintenance manual, at the time of the accident, were adequate to detect a mis-rig condition, when those checks were properly performed.

**6. RAC Proposed Safety Recommendation**

1. The FAA should ensure all 14 CFR Part 121 air carriers are following their approved maintenance program and that maintenance personnel are following all steps in the instructions, unless authorization has been granted in accordance with the air carrier's maintenance program.

Considering the above information, The National Transportation Safety Board should adopt the following probable cause:

Loss of pitch control during takeoff. The loss of pitch control resulted from the incorrect rigging of the elevator trim control system.

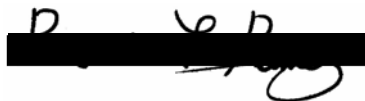
Contributing to the cause of the accident were:

1. Colgan maintenance technicians' failure to detect the incorrect rigging of the elevator trim control system.
2. Colgan quality assurance inspector's failure to detect the incorrect rigging of the elevator trim control system.
3. Colgan flight crew's failure to accomplish the preflight inspection procedures required by the Beech 1900D Airliner FAA Approved Flight Manual, Part Number 129-590000-3E, Section IV – Normal Procedures, specifically the first flight of the day preflight checks.

Should you have any questions, please email or call me at ( [REDACTED] )

Very truly yours,

RAYTHEON AIRCRAFT COMPANY



Robert L. Ramey  
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RLR

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