PARTY SUBMISSION OF

COLGAN AIR

TO THE

NATIONAL TRANSPORTATION SAFETY BOARD

COLGAN AIR FLIGHT 9446

BEECH 1900D, N240CJ

AUGUST 26, 2003

NEAR YARMOUTH, MASSACHUSETTS

NYC-03-MA-183

SUBMISSION OF COLGAN AIR

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Yarmouth, Massachusetts
August 26, 2003

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I. INTRODUCTION

Colgan Air is a certificated Part 121 scheduled air carrier operating under the trade name "US Airways Express." On August 26, 2003, at 1529 EDT, Colgan Air flight 9446, a Beech 1900D, FAA Registration No. N240CJ, was destroyed when it impacted water near Yarmouth, Massachusetts, shortly after takeoff from Barnstable Municipal Airport in Hyannis, Massachusetts. The occupants of the aircraft, the pilot and co-pilot, did not survive.

The aircraft had departed Hyannis on a post-maintenance repositioning flight en route to Albany, New York minutes before the accident. The flight was being conducted under 14 CFR, Part 91 General Operating and Flight Rules in visual meteorological conditions prevailed.

Colgan Air has participated in several phases of the accident investigation, and to the extent it has participated or where information has been made available, it has studied and analyzed the facts, conditions, and circumstances related to the accident involving Flight 9446. Based on this analysis of the facts of the accident and its participation in the NTSB investigation, Colgan Air has prepared this Submission which addresses the issues and facts of the accident. The Colgan Air Submission contains a discussion of the facts and circumstances of the accident, the pertinent issues, and the findings.

II. BRIEF HISTORY OF N240CJ

The accident airplane was manufactured and first sold by the Raytheon Aircraft Company, serial number UE-40, to Champlain Enterprises, Inc. dba CommutAir on March 29, 1993. The aircraft was in service with CommutAir until it was sold back to Raytheon Aircraft Company on October 10, 2000. The aircraft then remained at Raytheon's Aircraft Facility in Wichita, Kansas awaiting sale until it was leased by Raytheon Aircraft Credit Corporation to Colgan Air on a seven (7) year/eighty-four (84) month lease. It entered service with Colgan Air on January 4, 2003. It was in regular operation with Colgan Air up to and including the date of the accident.

III. MAINTENANCE ACTIVITIES ON N240CJ PRIOR TO ACCIDENT

A. CAMP Requirements

Colgan Air has a Continuous Airworthiness Maintenance Program (CAMP) that is divided into a series of checks and inspections, incorporating specific guidance from the Raytheon-authorized Beech 1900D Airliner Maintenance Manual.

N240CJ was in Hyannis for a "Detail Inspection;" one of six (6) discreet phases of maintenance. Specifically, the aircraft was undergoing a "Sixth" Detail Inspection, focusing on the Aft Fuselage and Empennage. This was performed on August 24, 2003 at 16,503.5 flight hours and 24,637 cycles. Of these amounts, 1219.1 hours had been generated by Colgan Air, and 1765 cycles had been accrued in Colgan Air service.

There was one (1) open Minimum Equipment List item at the time of the accident: Flight Data Recorder Inoperative (Elevator Trim Tab Parameter). This item was to be addressed by August 29, 2003 at Colgan Air's Albany, NY maintenance facility, to which the aircraft was enroute at the time of the accident. No open Aircraft Discrepancies existed at the time of the accident.

A single STC had been completed by Colgan Air which authorized the installation of a Flight Data Recorder and sensors.

Notably, an Emergency Airworthiness Directive had been issued and complied with in early 2003. Emergency AD 2003-03-18: *Elevator Rig Check* was accomplished as part of a Fleet Campaign Directive on January 31, 2003, and a follow-up AD was accomplished on February 2, 2003.

In the four (4) months preceding the accident, four (4) Elevator Pitch Trim maintenance issues on N240CJ, a Beech 1900D were addressed. On April 29, 2003, the pitch trim chain was re-tightened due to excessive slack. On July 9, 2003, the elevator trim tab servo was removed and replaced. On August 24,

2003, the left and right trim tab actuators were replaced as part of a Detail 6 Inspection. Lastly, on August 25, 2003, the right trim tab actuator was replaced and the forward trim cable was replaced.

B. Replacement of Trim Actuators

The work on the elevator trim tab system began on Sunday, August 24, 2003. As part of this Detail 6 inspection, the mechanics were required to remove and replace the elevator trim tab actuators because the actuators' operation did not meet the free play specifications. At the outset, the Colgan Air Supervisor consulted with Raytheon by telephone to verify the trim tab actuator part numbers and to ensure they had the proper actuators for installation on the accident aircraft as the Raytheon IPC indicated Colgan Airs' available spares (Part Numbers 129-526033-6 and -7) (a -7 actuator was removed from the left side for replacement that night) were proper for use on the aircraft. Raytheon Technical Support indicated that there were Service Bulletin kits available that would convert the -6 and -7 actuators to -27 and -29 respectively; however, the tech indicated that he thought the -6 and -7 actuators would work. Because of the time required to order the mod kits, ship the kits, then modify the actuators and install the modified actuators, Colgan Air requested from RAC Technical Support engineering approval to use the -6 and -7 actuators that were on hand. The -6 and -7 actuators were operationally the same as the -27 and -29. The Service Bulletin kits essentially modified the actuator seals and lubricant to improve cold weather operational reliability. While waiting for a response from engineering support, Colgan Air, maintenance personnel elected to install the -6 and -7 actuators with the understanding that engineering approval would be required before they could complete documentation of the installation. Informal verbal confirmation from Raytheon indicated that the -6 and -7 actuators would work so the Colgan mechanics installed the -6 and -7 actuators in anticipation of a formal confirmation from Raytheon engineering the following morning. Thus insufficient technical data and the absence of timely engineering assistance was the first event in the chain of events that culminated in an accident.

C. Necessity for Elevator Removal when Replacing Trim Actuators

In his interviews with the Airworthiness Group, the lead mechanic acknowledged that they did not remove the elevator. Instead, they pinned the elevator and obtained access to the maintenance areas in question through access panels in the stabilizer.

The mechanics failed to follow the manufacturer's AMM Revision 9 instruction and Colgan Air Detail 6 work cards to remove the elevator as part of the scheduled elevator trim actuator removal and reinstallation. In the mind of the Colgan mechanics it was thought that they actually performed the R & R of the elevator trim tab actuators in a safe manner because they avoided having to disengage or remove major elements of the flight control system, and disrupted a much smaller portion of the airplane. The actuators could be easily observed, accessed, removed and replaced through the removal of only select inspection panels. Although they did not remove the elevator Colgan Air mechanics removed and replaced the elevator trim tab actuators correctly as specified in the manufacturer's AMM Revision 9. This fact was substantiated by inspection of the actuators during the investigation subsequent to the accident. That aside, failure to remove the elevator during elevator trim tab actuator replacement had no bearing on the accident.

D. Forward Elevator Trim Cable Replacement

After installing the new actuators referenced above, the Colgan Air lead mechanic noticed a problem. While performing rigging checks, the mechanic in the cockpit working the trim wheel felt the wheel "bind" or "stick." Unfortunately, in conducting operational checks of the trim system, the new actuators, extended or retracted at a dissimilar rate and the trim tab cable loosened or kinked. Upon inspection, the mechanics observed that the cable had kinked, started to unravel, and popped off of the drum thus requiring replacement.

The Supervisor on duty again called Raytheon about the problems, and a Raytheon representative stated, before the Colgan Air maintenance supervisor could finish his account of the event, something to the effect, "Let me guess? The cable popped off the drum?" This certainly evinces a knowledge by Raytheon of an ongoing and previously encountered problem with the rigging of elevator trim tab cables and replacement of elevator trim actuators on the Beech 1900D. The Raytheon representative then stated that installation of an incorrect dash number actuator on the aircraft could cause the cable to come loose from the drum and become kinked.

The Lead Colgan Air mechanic at the time directed removal of the right actuator and ordered a new cable and the replacement actuator. These parts arrived late on Monday, August 25, 2003. The same lead mechanic then oversaw and participated in the installation and testing of the new parts.

The following sequence occurred with regard to removing and replacing the forward elevator trim tab cable. The supervisor removed the damaged forward cable from the cable drum and secured it to the pedestal. Upon receiving the new forward elevator trim tab forward cable, the lead mechanic assumed the remainder of the forward trim cable removal and reinstallation task. He described in detail the AMM Revision 9 removal process and because the prescribed procedure for replacement of the forward cable required removal of some pulleys it compromised the effectiveness of using lead lines (see note below). As a result an alternate method of cable removal and installation was developed and used.

> NOTE: Reps AMM Rev 9, 27-30-04-201 step c. Some of the pulleys cannot be cleared by the stops and turnbuckles even with the retaining pins removed. Remove those pulleys where necessary to provide adequate clearance

The Lead described how they marked the pulley mount that the left hand threaded cable was routed through with a T as they were removing it., Installation was accomplished using the "T" marks to orientate the left hand treaded cable end runs to ensure the cable was routed through the exact pulleys the old cable had been removed from. The old and new cables were compared, and the new cable was marked with red nail polish to indicate where the FDR Bridle had been installed on the old (damaged) cable. The "T" marking on the pulley brackets allowed the mechanics to duplicate the cable routing for the left hand threaded end of the cable.(as it is a single metal cable with no manufacturer's markings to assist the installing mechanics). The practical effect of the marking system is to provide a foolproof way to trace the proper routing of the cable in accordance with the diagram provided in the manufacturer's maintenance manual.

> NOTE: It is possible to route an incorrectly wound forward elevator trim cable through the cable pulleys and never detect a perceptual visual cross in the cable run if that cross over is at the 5th pulley set (one pulley stacked on top of the other) and where the cable routing changes to a left and right orientation.

Following the manufacturer's maintenance manual, the mechanic participated in the winding of the new cable around the drum and specifically discussed with the other mechanics how the cable needed to go in a particular direction around the drum (discussed further in section IV, Manufacturers Maintenance Manual). Further, he stated that he was certain the elevator trim tab cables were not crossed because he checked them personally. He described in detail to the Group Chairman how he and the other mechanics checked and rechecked the operation of the trim wheel and the movement of the trim tab, including his personal visual inspection. The specified limits of travel at full nose down, zero degrees, and full nose up were recalled to be checked, and the numbers were as specified in the manufacturer's manual.

As will be discussed further, the maintenance manuals do not specify a method by which to conduct an operational check of the work performed. Absent specific detailed operational check instructions, a mechanic may reasonably interpret an operations check to consist of making sure that the tab throw is consistent with the degrees of movement specified in the installation instructions and not correlate this with the direction of the tab movement. In this case, the NTSB obtained the statements of the mechanics concerning their work, and how they confirmed that they checked the travel of the trim tab using a digital protractor; an acceptable alternate tool to the rig boards suggested by the manufacturer. In fact, what the mechanics did was well beyond what the manufacturer suggests as the maintenance manual was silent on any operational check of the system.

E. Night Shift Work

One item of apparent focus in the oral interviews of the mechanics was the fact that the maintenance, and the Detail 6 inspection/check, was performed by a crew working the night shift. All of the men interviewed stated that they were not fatigued, were not ill, were not experiencing any undue stress at work or at home, and had no difficulty obtaining rest through sleep during their non-working hours. They were not rushed to complete the job.

IV. DEFECTIVE NATURE OF THE MANUFACTURER'S MAINTENANCE MANUAL

Colgan Air submits that the Raytheon Maintenance Manual Rev 9, 27-30-04, Figure 201 for the Beech 1900D is, by their own admission, defective as it relates to the pictographic instructions for the routing of the elevator trim tab actuating cable. While the plain English description of the step-by-step procedure to be followed is correct in its wording, the pictographic depiction is unclear, and in fact misleading and incorrect. The pictograph in the manual states in small print at the bottom of the diagram that the drawing as shown must be rotated 90 degrees counterclockwise to imitate the running path of the cabling. First and foremost, this is cumbersome and not easily grasped. More importantly, though, is that it is only half of what the mechanic needs to do to obtain the accurate mental picture of the cable routing. The next step, which is not stated in the manual, is that the pictograph is reversed! In other words, the drawing is in the manufacturer's maintenance manuals backwards!

What is even more egregious is that this is not articulated anywhere in the manual. Therefore, what the manufacturer has presented to the line mechanic is a maintenance diagram that must first be rotated 90 degrees to the left and then flipped backwards to be fully correct. The presence of the pictograph is more than a visual aid or mere illustration. It is a representation and form of instruction, and its' blatant inaccuracy presents an insidious mental picture that can and will lead to misrigging of the cable even though the mechanic follows the word instructions.

It is human nature to default to an illustration over words, and the aircraft manufacturer knows or should know that. Any denial of this fact by Raytheon is, at a minimum disingenuous. By allowing an incorrect technical drawing to remain in a service manual such as exists here is to predispose an air carrier to the precise event that occurred. The defective illustration was a critical link in the chain of events that culminated in the Hyannis accident involving N240CJ.

Problems with illustrations in the Raytheon manuals are not an isolated event. As yet another example, Figure 202 from the maintenance manual is, from the perspective of a mechanic, either upside-down or backwards or both, depending on what the mechanic is doing. A mechanic seeking to adjust the cams or work on other parts of the Flap Limit Adjustment Cams assembly will approach the assembly from the trailing edge of the wing, with the flaps extended giving access through the access port on top of the wing or access directly from under the wing. There is no way to access or view the assembly from a position by the wing leading edge, facing aft, as the assembly is mounted to the aft side of the wing spar. Yet the view presented in Figure 202 is from forward and above the leading edge. The only way the mechanic could approximate the view in the figure is to lay on the wing with his head pointing toward the tail and his feet hanging over the leading edge, and then look down into the access port. Even from this ridiculous position the figure would be upside down, but, at least, it would not be backward, as well. From under the wing flap looking forward, the mechanic has the best access to the full assembly, but then the drawing in Figure 202 is both upside-down and backwards. Because the mechanic will always approach from the trailing edge side, and since the access port and the assembly itself are on the aft side of the wing, Figure 202 invites error because the numbered cams are in reverse order from that depicted in the Figure.[1]

Additionally, and perhaps most notably, the manufacturer's maintenance manuals were silent with respect to any method or manner of operational checks for a mechanic to check the work on the trim system once it has been completed. There was no checklist, flowchart, description or other instructions for a diagnostic operational check of the pitch trim control system after the performance of the work that was done in this case. In other words, the manufacturer has left the mechanic and end user with no guidance as to how to check the efficacy of the work performed. Work, which if performed in compliance with Raytheon's instructions, will result in a dangerous and, in the case of this accident, deadly condition.

[1] The drawing of the Flap Travel Limit Switch contained in the Raytheon IPC is identically positioned to Figure 202, inviting confusion when selecting replacement parts.

V. ERRONEOUS STATEMENTS CONTAINED IN RAYTHEON'S MAY 6. 2004 SUBMISSION TO THE BOARD

Raytheon Aircraft Company's May 2004, letter Submission to the Board is rife with inconsistencies and erroneous assertions. Colgan Air, Inc. is gravely concerned with this manufacturer's submission. It demonstrates two things; an ill-concealed attempt to mislead the Board into laying the blame for this incident at the feet of the flight crew and maintenance personnel, and a startling and disconcerting lack of knowledge of the aircraft and accompanying manuals that they have placed into the stream of aviation commerce.

A. Raytheon Approved the Actuators

In the first paragraph of page 2 of the Raytheon Submission it is states: "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." In fact, the Colgan Air representatives with guidance from RAC Airline Technical Support decided to replace the -6 with a -9 actuator. A simple look at the Illustrated Parts Catalog tells the reader that ***none of these dash numbers can be used in the aircraft involved in this matter***, including the -9 which was not included in the effectivity group for UE 40, the accident aircraft. (see foot note 1 below)

Raytheon would like the Board to believe and conclude that the Colgan Air mechanics were confused or knowingly installed the wrong actuators. In point of fact, Raytheon told the mechanics to go ahead and install the -6 and -7 actuators. The problem with identifying the proper actuator to install is directly the result of Raytheon's consistent failure to adequately support maintenance of the 1900 through its maintenance manual and Illustrated Parts Catalog.

The review of the history of the decision to install the -6 and -7 actuators in the accident aircraft is appropriate, as Raytheon seems to have overlooked its participation in it:

When it was determined during the Detail 6 check that both actuators would have to be replaced, the mechanic supervisor at Hyannis checked the IPC to determine what actuators should be installed.

The IPC, at pages 14-15, provided the Codes of Effectivity for Elevator Trim Tab Actuators. The accident aircraft Serial was UE-40. Looking at the list of the Codes, it was determined that Codes B, D, J, and M were applicable to the accident airplane. Looking at the list of actuators (IPC, pp. 5-8), the mechanic found the following actuators as permissible to use:

Code B: None
Code D: -3
Code M: -27, -29
Code J: -1, -2

As a practical matter, the -1, -2 and -3 were old mods no longer used. A review of the IPC shows the -27 and -29 were the replacement mods for the majority of actuators in use, such as the -6, -7 and -9.

However, what the mechanic learned, when he called the Beech part supplier, was that while Raytheon had modified the IPC to show the -27 and -29 as the replacement part for most actuators and to show those older mods as unavailable for use in aircraft such as the accident aircraft. Neither the -27 nor the -29 were available for the operators.

The mechanics at Colgan did have available -6 and -7 actuators, however, neither was listed in the IPC as usable with the accident aircraft. Raytheon Aircraft Service Bulletin 27-3032, issued in July 2003, called for mandatory modification of spare -6 actuators, and recommended modification of spare -7 and -9 actuators, but the IPC did not indicate that unmodified actuators could be utilized in the accident aircraft.[1]

[1] The -27 is listed as the replacement actuator for the -7 and several other actuators, and the -29 is shown as the replacement for the -6 and the -9, as well as other actuators, but the entries do not inform the mechanic whether the converse is proper, i.e., that a -9, for example, can be used in lieu of a -29.

Uncertain of what could be used in the accident aircraft, the Colgan mechanic called the Raytheon Airline Technical Support Group around 2:00 a.m. on the morning of August 25, 2003, to determine whether the -6 and -7 actuators could be used, since the -27 and -29 were not yet available.[2] At the request of the Raytheon tech, the Colgan Supervisor sent an email request to the tech at Raytheon, requesting a Configuration Change to allow Colgan to use the -6 and -7 actuators.[3] (A copy of this email is attached to this Submission.) Apparently after reviewing drawings, the Raytheon tech advised the Colgan Supervisor that use of the -6 and -7 was acceptable to him, but would have to be confirmed by a Raytheon engineer. He advised that, at worst, the actuators would have to be removed and replaced if the engineer did not approve. Based on the Raytheon tech's statement that it was acceptable for Colgan to install the -6 and -7 actuators, pending an engineer's approval, the Colgan Supervisor went ahead and directed that the actuators be installed.

Subsequently, the forward trim cable came off the drum and it was determined that the -6 actuator had to be replaced by a -9, pursuant to Raytheon's directive, although the -9 also was not authorized by the IPC for use in the aircraft.

At the time of the accident, the Raytheon IPC called for installation of actuators that were not available. Although not reflected in the IPC and therefore unknown to mechanics, older actuators modified by Kits identified in a July 2003 Service Bulletin apparently could be used. Further, unmodified actuators apparently also could be used. However, a mechanic had to rely exclusively on Raytheon's hot line to determine what mods were actually available to be used and in what aircraft. At best, this is a convoluted and confusing procedure, and it fully explains why the Colgan Air mechanics called Raytheon for technical assistance.

In addition, the first page of the computerized Illustrated Parts Catalog on "Actuators" also poses a trap. After listing seven of the actuators, it shifts to "Push Rod Assemblies," with no warning. Then, on the next page, it shifts back to "Actuators." There is no reason for the reader to scroll past Push Rod Assemblies to the next page to continue searching for Actuators. Unless the mechanic stumbles onto this trap, or is familiar with it from previous experience, it will remain likely (if not certain) to confuse mechanics.[4]

B. Maintenance Manual Revision on Digital Protractor

Raytheon's submission at page 2, attacking the Colgan Air mechanics' use of a Digital Protractor to check the trim tab travel in lieu of a Travel Board, states, "[t]he maintenance manual offers no provisions for using a digital protractor for this procedure and offers no guidance on their use." Quite simply put, this statement is blatantly incorrect and constitutes an effort to mislead the Board, or demonstrates the Raytheon Submission's author's complete lack of familiarity with the Raytheon manuals and publications.

Referring to the Raytheon Maintenance Manual's Table of Contents, Flight Controls - Description and Operation, one finds an entry titled "Special Tools and Recommended Materials." Accessing this entry takes the mechanic to **Chart 1**, Special Tools and Equipment. There the mechanic finds listed:

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[2] The Raytheon tech advised that the -6 and -7 could be used, if modified by the applicable Kits identified in Service Bulletin 27-3032. The Supervising mechanic at Colgan advised the Raytheon tech that Hyannis was a remote repair station not in a position to do modifications on parts and that he had no authority to modify parts for further installation in operational aircraft.

[3] In point of fact, -6, -7 and -9 actuators were still apparently operationally usable, since the only changes made by the Kits related to improving cold weather reliability by sealing the housing to minimize moisture and to change the type of grease used. See Raytheon Service Bulletin 27-3032.

[4] All of the foregoing is predicated on Revision 9 to the Raytheon Maintenance Manual. Revision 10 was released by Raytheon a very short period of time prior to the accident. However, it was not sent to Colgan Air, Inc. by Raytheon until the day before the accident. Even if Colgan Air had received Revision 10 the next day (the accident date), there would not have been sufficient time for it to have been implemented system-wide.

Item 6, Elevator Tab Travel Board. However, immediately below the Special Tools and Recommendations entry in the Table of Contents, the mechanic also finds the entry "**Temporary Revision**, TR27-7 (**Chart 1** and 3)." Accessing this entry takes the mechanic to a list of revisions to **Chart 1**. Here, **Item 6** has been revised by Raytheon to read, "Elevator Trim Tab Travel Board **or Digital Protractor** (Item 18)" [emphasis added]. Raytheon cannot escape its own computer based Maintenance Manual and Revisions thereto.

C. Lead Mechanic did not Re-Index the Trim Tab Wheel

Additionally, Raytheon would have the Board believe that the Colgan Air Lead Mechanic, gave a statement that he "re-indexed" the elevator trim tab wheel on the cockpit pedestal to zero. In fact, he never made such a statement and has emphatically stated to Board representatives time and again that the trim tab wheel was **not** re-indexed after the cable was re-installed. [5] The Raytheon submission openly mischaracterizes Mr. Kinan's statements. He has never stated that the wheel was re-indexed.

D. Trim Drum Illustration was Backwards

Finally, Raytheon admits that its Maintenance Manual was defective with respect to the technical illustration of the trim drum and the cable orientation. However, Raytheon buries this admission of error in text on page 3 of its submission, and dismisses its glaring causative error with a single sentence. Following that admission, Raytheon further attempts to gloss over its mistake by offering that a Temporary Revision was issued on September 12, 2003, correcting the mistake; eighteen (18) days too late for Colgan Air Flight 9446. Then, in a gratuitous slap in the face to Colgan Air and its mechanics, at page 5 of the submission, Raytheon states its defective and misleading technical drawing has existed "in the Model 1900 series Maintenance Manuals since 1984 with no prior report of problems." Simply because Raytheon disclaims knowledge of prior reported problems does not obviate the fact that their Maintenance Manuals were defective, and by their own admission have existed in a defective manner for 20 years.

VI. DISCREPANCIES IN FDR DATA LEADING TO INHERENT UNRELIABILITY

The Flight Data Recorder of N240CJ was recovered and sent for analysis. The evaluation of the data obtained revealed numerous error points which render the data obtained as inherently unreliable and an insubstantial basis upon which for the Board to make any findings or conclusions.

A. Pitch Control System

As a first example, in examining the Pitch Control parameter, it was determined that displayed values for the accident flight were inconsistent with normal operation, suggesting that the pitch control sensor was out of calibration. The interpreter was forced to default to examining pitch control data from "all previous flight data recovered" which was approximately 97.6 hours. In a review of all that data, which itself may have been flawed, it was determined that the maximum trailing-edge-up position was never achieved. The interpreter noted, though, that the trailing edge up and trailing edge down positions are the *only* credible post accident calibration points for the accident aircraft elevator system. Given this fact, and the fact that the TEU position was never recorded in the 97.6 hours of retrievable data, any reliance on the FDR parameter for pitch control is inherently flawed. Furthermore, in an attempted extrapolation of the maximum TEU value, it was acknowledged that TEU values from a single observation add to the uncertainty, and there is no reliable way to verify the mid-range unit values derived in the post accident analysis. The pitch control data from the FDR should be altogether ignored.

[5] In the transcript of Mr. Kinan's interview with Mr. Carbone on August 27, 2003, Mr. Kinan is asked a series of questions relating to the work on the trim (page 23-24). Mr. Kinan agreed that everything went straight in," and that he reset the indicator "to zero." He then went on to say no work was done on the trim during the maintenance. As Mr. Kinan has explained during his discussions with the investigators, once the drum was rewound, it was set back into place at the zero position. No re-indexing was required or done.

Additional basis for this conclusion is obtained from the fact that the position of the pitch control sensor at the opposite end of the pitch control system as measured from the elevator control surfaces "provided ample opportunities for calibration variances." When measured as a curve on a graph, the evaluator concluded:

> As a result of the non-linearity and aircraft specific nature of FDR pitch control calibration data, an accuracy determination of elevator position through the full operating range following a catastrophic accident [is] highly unlikely. Therefore, the pitch control data recorded by this FDR should be considered as trend data only.
>
> The evidence shows that the accident aircraft pitch control calibration characteristics did not match any of the three aircraft specific calibrations referenced in this study. Therefore, it is apparent that the Beech 1900D FDR pitch control sensor calibration is sufficiently unique from aircraft to aircraft to warrant an airplane specific calibration.

B. Pitch Trim Control

The maintenance activities described in Part III above resulted in a changed relationship between the pitch trim tab position and the FDR pitch trim sensor. The removal and replacement of the cables controlling pitch trim affected the FDR pitch trim sensor attached to the cable, and as a direct result, all of the Pitch Trim Control recorded values during the accident flight were out of calibration. In conducting an analysis, and attempting to conform and reconcile the data, the evaluator selected "comparison data" from the first forty (40) takeoffs recorded on the FDR. The immediate and obvious question that jumps to mind is: "Why?" How many takeoffs were recorded on the FDR? Under what conditions (loading, weather, etc.) were those takeoffs conducted? Why choose 40? Why not 20? Why not 60? Why not all? Mainly, why any at all?

Knowing and admitting that the Pitch Trim Control sensor was out of calibration is sufficient to warrant a discontinuation of any further work on that parameter of FDR measurement. One cannot extrapolate from a limited sampling of prior data retrieved from an FDR that is demonstrated to be out of calibration, a value or trend, and then go the extra step of holding forth the extrapolation as fact. The resulting conclusions are the fruit of the poisonous tree. With the underlying data so badly flawed, the conclusions from educated guesses based on a non-scientific sampling of unverified data are similarly flawed. When an evaluator must "theorize" actual trim tab position, then that evaluator's entire study is just that: "theory." The Board's work in these matters is too important and too valuable to be based on "theorizations" of extrapolations of flawed and non-scientific data. Further, when the evaluator acknowledges in his report that there are serious questions about "data fidelity" which may have resulted in some of the first 40 takeoffs being "misidentified," such a large shadow of doubt and questionable credibility is cast over the report that it must be ignored.

Based on the foregoing, any information obtained from N240CJ's flight data recorder must be discounted as unreliable, and should further not be used by the NTSB in the preparation of its final report and findings.

VII OPERATIONS FACTORS

A. CREW HISTORY

The crew was asked to fly the aircraft to Albany, NY to facilitate calibration of the Flight Data Recorder. The flight crew was adequately rested, current and qualified in the Beech 1900C/D model aircraft. Crew Qualifications, rest and duty time were **not** factors in this accident.

B. CHECKLIST AND MANUAL GUIDANCE

The crew accomplished an internal and external preflight in accordance with the Beech 1900D Company Flight Manual and the Flight Operations Policy and Procedures Manual (FOPP) to determine the airworthiness of the aircraft to be flown. They reviewed in detail the Aircraft Maintenance and Flight

Log. Attention was given to the MEL that addressed the Flight Data Recorder as verified by the CVR. In accordance with Colgan Air procedures, a valid Airworthiness Release was documented within the Aircraft Maintenance and Flight Log. There being no apparent discrepancies, the crew proceeded to prepare for the flight. These actions are evidenced by the voice transcript of the CVR. It should be noted that there were 17 minutes of recording on the CVR that were not addressed in the voice transcripts because of the nature of most of the comments, i.e., sounds of maintenance activities, unidentified or unintelligible voices and hammering. This first portion of the voice recording was generally of poor quality and meaningful conversations could not be discerned.

All checklists were accomplished in order and in accordance with the appropriate Beech 1900D Company Flight Manual. Once power was applied to the aircraft the latter and intelligible portion of the CVR (*fidelity* of recording was poor to good) verified professional crew discipline and adherence to procedures. There were no significant delays or interruptions to checklist completion detected in a review of available CVR transcripts. The determination of whether to restart the checklist as a result of a perceived interruption is a subjective one and experience indicates this is rarely necessary.

Considerable discussion has centered on the trim check described as a part of the First Flight of the Day Checklist. Since the Raytheon expanded checklist is considered an FAA boilerplate model for operators to use in the operation of the Beech 1900D, Colgan Air centered their attention on the adequacy of the Raytheon Aircraft Flight Manual (AFM) trim check. This focus revealed significant deficiencies and omission of logical cross checks in the Raytheon AFM procedures. Specifically, they only address the *ELECTRIC TRIM* and methods to determine its operation and the ability of the captain to override the first officer electric trim inputs. Our evaluation of the accident data has indicated that it would more appropriate if this check were used to verify that the electric trim is causing the manual trim wheel to move in the correct direction in addition to testing the system continuity and the ability to disengage the electric aspects of the elevator trim function.

Even if the forward trim cable had been installed incorrectly as discussed in previous sections of this report, the crew would not have been able to detect a misaligned trim tab position during the walk around phase of the preflight. Several units of trim in one direction or another could not be seen by the pilot during the walk around pre flight of the aircraft.

C. CREW PERFORMANCE

Although the Beech 1900D Airliner FAA Approved Flight Manual (AFM) addresses Unscheduled Electric Elevator Trim, it is a silent procedure with memory steps incorporated to ensure timely response. The CVR transcripts verify that the crew was attempting additional steps to deactivate the electric trim with the switch on the pedestal as well as attempting to open the appropriate circuit breaker. The follow up checklist items conform to the response protocol and are called out by the non flying pilot.

The Colgan Air Beech 1900 Company Flight Manual section for emergency procedures (UE Airplanes) included a checklist for "UNSCHEDULED ELECTRIC ELEVATOR TRIM (IF INSTALLED)."

Emergency Checklist

The memory items (to be performed by the flying pilot) were;

1. Airplane Attitude.....**MAINTAIN** (using elevator control)

2. Control Wheel Disconnect Switch.....**DEPRESS FULLY (PITCH TRIM OFF** Annunciator ILLMINATED)

The follow up checklist items were;

3. Manually re-trim airplane

4. Elev Trim Switch (located on the pedestal).....OFF (PITCH TRIM OFF Annunciator EXTINGUISHED)

The follow up checklist is a command and response checklist, with the corrective task being

accomplished by the NFP at the direction of the captain.

The CVR transcripts make it obvious that the crew accomplished the memory items associated with the UNSCHEDULED ELECTRIC ELEVATOR TRIM checklist and they were struggling to maintain control of the aircraft while further disabling the electric trim and trimming the aircraft manually.

Subsequent simulator evaluation scenarios confirmed that it was likely improbable that the aircraft could be controlled and return to the field with aircraft configurations similar to those established by the Operations Group. In five (5) of the six (6) simulator evaluation scenarios it was concluded that the aircraft was not recoverable.

The FSI simulator was an FAA certified Level "D" Beech 1900 full motion simulator. It had cockpit controls and displays similar to the accident airplane with some minor differences. The Operations Group agreed that 1 unit of trim movement on the manual trim wheel, would equal 1.6 degrees of trim tab movement on the elevator. Due to the limitation of the simulator trim system, the maximum downward trim setting was about 5 units. The trim system was not reversed for the tests.

The simulator was pre-programmed with the following parameters:

Departure Airfield - HYA runway 24
Takeoff weight - 13,907 pounds
Fuel - 3,200 pounds
C.G - 281 inches
Flaps - 0 degrees
Power Setting - 3,500 pounds of torque
Temperature - 23 degrees Celsius
Wind - 240 degrees at 5 knots

D. STERILE COCKPIT CONCEPT

The crew observed all aspects of the ***Sterile Cockpit Concept*** throughout the audible, recorded portion of the flight. Although there was conversation in the cockpit that in part, related to other than that particular flight, they occurred prior to the Before Start Engines checklist and preceded the time period that is commonly considered as part of a Sterile Cockpit. Pilot to pilot conversation while waiting for landing traffic just prior to the Colgan Air departure were considered to be part of crew coordination and situational awareness.

VIII. PROPOSED FINDINGS OF FACT

Based upon all of the foregoing, and drawing upon independent tests and analysis by Colgan Air, the following proposed findings of fact are respectfully submitted.

A. Maintenance On The Pitch Control System and Pitch Trim

- The Colgan Air Continuous Airworthiness Maintenance Program (CAMP) satisfied all requirements of 14 CFR 121, and all other applicable FARs.
- The Lead Mechanic for the maintenance in question was qualified, experienced, and supervised the operation effectively.
- The line mechanics involved in the maintenance in question were qualified and experienced personnel, and they performed the maintenance effectively.
- The Colgan Air Continuous Airworthiness Maintenance Program (CAMP) was effective and had provided a safe, efficient basis for the Colgan Air 14 CFR Part 121 maintenance requirements.
- The Colgan Air Maintenance Program Manual and the Colgan Air General Maintenance Manual satisfied the requirements of 14 CFR 121, and all other applicable FARs, and

clearly established the maintenance program and procedures that Colgan Air and the FAA required to be followed to fulfill the requirements of the Federal Aviation Regulations.

- The Colgan Air maintenance program was, consistent with safety and practicality, conducted in accordance with the manuals. There was no record of deficiencies in the Colgan Air Maintenance Program Manual or General Maintenance Manual.

- The responsibilities of the lead mechanic and maintenance technicians for the Detail 6 inspection on August 24, 2003, were clearly established in the Colgan Air manuals.

- The Colgan Air Hyannis maintenance facility was staffed properly to perform the Detail 6 inspection and the maintenance in question.

- Based upon the interviews conducted by the NTSB on the day following the accident, and the corroborating information obtained from the interviewees, it was determined that the elevator trim tab cable was installed as indicated by the manufacturer's maintenance manual, and the mechanics (Lead and Inspector) believed that proper operation of the elevator trim tab was observed and properly tested at the conclusion of the maintenance.

B. <u>Defective Nature Of The Manufacturer's Manual</u>

- The Aircraft Maintenance Manual for the Beech 1900D contains both technical word instructions as well as an illustrative pictograph of the elevator trim tab actuating cable and pulley system, including the routing details.

- The pictograph in the Aircraft Maintenance Manual for the Beech 1900D concerning the elevator trim tab cable routing, as printed in Revision 9 and in use in August 2003, required the user to rotate the drawing 90 degrees counterclockwise as a first step toward obtaining proper orientation of the diagram to the aircraft system.

- The pictograph in the Aircraft Maintenance Manual for the Beech 1900D concerning the elevator trim tab cable routing, as printed in Revision 9 and in use in August 2003, is backwards or reversed, and that fact is not specified in the manual to the user.

- The pictograph in the Aircraft Maintenance Manual for the Beech 1900D concerning the elevator trim tab cable routing, as printed in Revision 9 and in use in August 2003, requiring the user to rotate the drawing 90 degrees counterclockwise as a first step toward obtaining proper orientation of the diagram to the aircraft system, and further not warning the user that the diagram is in fact wrong as shown, renders the diagram inherently unreliable, and poses a safety of flight issue.

- By not warning the user of the Beech 1900D Aircraft Maintenance Manual that the pictograph concerning the elevator trim tab cable routing, as printed in Revision 9 and in use in August 2003, the user is lead into reversing the cable pattern, thinking that the cable was in fact properly oriented.

- The manufacturer's maintenance manuals are defective by virtue of their lack of any operational check procedures which would provide a mechanic with guidance and instruction as to how to verify that he or she has in fact routed the pitch trim cable properly. This is heightened by the fact that the manuals' instructions on how to perform the task itself are confusing and, in fact, incorrect by virtue of the reversed technical drawing.

- The Raytheon IPC is unclear and confusing as to the proper trim tab actuators to be installed.

- The Raytheon 1900D Airliner FAA Approved Flight Manual (AFM), Part Number 129-590000-3E, Section IV, Normal Procedures for the First Flight of the Day is inadequate

and deficient. The Elevator Trim System check is deficient and lacking in clarity and substance in that the focus is aimed at solely checking various override functions of the electric elevator trim and its' deactivation. While this aspect of the electric elevator trim is important, the check should have been expanded to provide guidance for the pilot that references the relationship between movement of the electric trim switch to the corresponding movement of the manual trim wheel.

C. FDR Discrepancies Render Findings Unreliable

- The fact that the Pitch Control parameter is acknowledged to be out of calibration on the accident aircraft renders any data from the FDR unreliable, as regards pitch control.

- The Beech 1900D pitch control sensor calibration has been demonstrated to be unique from one aircraft to another. As such, each Beech 1900D warrants its own distinct FDR calibration for pitch control data. Not having a reliable calibration point for the accident aircraft's pitch control renders any data on pitch control derived from the FDR as having "trend value" only.

- The Pitch Trim Control sensor on the accident airplane was demonstrated to be out of calibration as a result of the maintenance on the pitch control trim cable performed shortly before the accident.

- Inherent questions of data fidelity, even when attempting to compare up to forty (40) prior takeoffs to attempt to find reliable data, including the distinct possibility that some of the sampling data may have been misidentified, renders the Pitch Trim Control data from the accident aircraft FDR as inherently unreliable.

IX. Recommendations

A. To Raytheon Aircraft Company:
Consistent with NTSB Safety Recommendation A-04-13, review all maintenance procedures/instructions to eliminate unnecessary actions, such as the requirement to remove the elevator during replacement of trim tab actuators, which existed at the time of the accident.

B. To Raytheon Aircraft Company:
The maintenance manual be revised to accurately describe and depict the removal, winding and replacement procedure for the cable drum assembly associated with the elevator trim tab cables.

C. To Raytheon Aircraft Company:
The AFM be revised to incorporate an elevator trim tab check that references correlation between the Electric Trim movement and that of the manual trim wheel, i.e., when nose down electric trim is selected, a corresponding movement is verified on the manual trim wheel. The same comparisons should be called for when nose up electric trim is selected. Appropriate checklists should be revised to call for a detailed check of all trim systems.

D. To the Federal Aviation Administration:
In light of the known errors and deficiencies in the maintenance manual, AFM and the errors, omissions or misrepresentations contained in Raytheon's submission to the Board, consistent with NTSB Safety Recommendation A-04-24, the FAA should commence a special inspection and review of Raytheon Aircraft Company maintenance manuals and programs for the Beech 1900 aircraft.

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