



# National Transportation Safety Board

Washington, D.C. 20594

## Safety Recommendation

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**Date:** May 28, 2010

**In reply refer to:** A-10-96 and -97 and  
A-04-11, -15, and -16 (Reiteration)

The Honorable J. Randolph Babbitt  
Administrator  
Federal Aviation Administration  
Washington, D.C. 20591

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On December 14, 2008, about 1700 eastern standard time (EST),<sup>1</sup> a Bombardier CRJ CL-600-2B19, N407AW, operated as Air Wisconsin Airlines Corporation (AWAC) flight 3919, landed with the left main landing gear (MLG) in the retracted position at Philadelphia International Airport (PHL), Philadelphia, Pennsylvania.<sup>2</sup> The two flight crewmembers and one flight attendant aboard the airplane were uninjured, and the airplane sustained damage to the left wing, aileron, and flap. The flight was operating under the provisions of 14 *Code of Federal Regulations* (CFR) Part 121 as a nonscheduled positioning flight from Norfolk International Airport (ORF), Norfolk, Virginia, to PHL. An instrument flight rules (IFR) flight plan was filed.

The National Transportation Safety Board's (NTSB) investigation of this incident is ongoing. However, based on preliminary findings from this investigation, as well as prior investigative findings, the NTSB is concerned about training for mechanics and inspectors.

### Training for Mechanics

On December 13 and 14, 2008, the incident airplane underwent extensive maintenance at the AWAC maintenance facility at ORF, including the removal, replacement, and visual inspection of the left and right MLG uplock assemblies (see figure).<sup>3</sup> The work order indicated that this task was a required inspection item (RII).<sup>4</sup> Mechanics were only able to work on one assembly at a time due to the confined space in the wheel well, so the work was divided between

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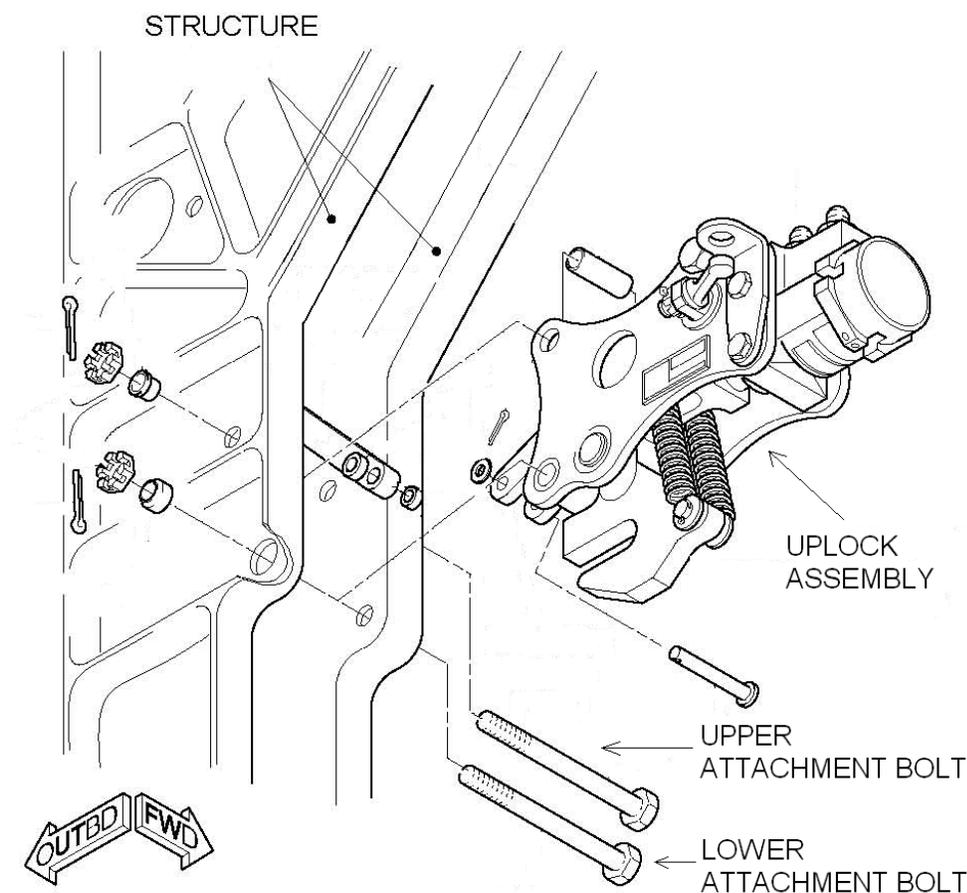
<sup>1</sup> All times in this letter are EST unless otherwise noted and are based on a 24-hour clock.

<sup>2</sup> Preliminary information regarding this incident, NTSB case number DCA09IA017, is available online at <<http://www.nts.gov/ntsb/query.asp>>.

<sup>3</sup> The MLG uplock assemblies are responsible for mechanically locking the MLGs in the fully retracted position. Two bolts attach each uplock assembly to the structure.

<sup>4</sup> According to 14 CFR 121.369(b)(2), an operator's manual should contain a designation of the items that are RIIs, which "could result in a failure, malfunction, or defect endangering the safe operation of the aircraft, if not performed properly or if improper parts or materials are used." The person performing the RII maintenance task may not perform the required inspection of that item.

two mechanics. The NTSB's investigation revealed that the mechanic who replaced the left uplock assembly (the incident mechanic) had not replaced an uplock assembly prior to working on the incident airplane, had not received on-the-job training (OJT) for this task (it was not required for this task), and was not being supervised during the procedure.<sup>5</sup> In a postincident interview, the incident mechanic stated that he relied on AWAC's General Maintenance Manual (GMM) and the mechanic who was replacing the right uplock assembly for guidance.<sup>6</sup> However, when the incident mechanic replaced the left uplock assembly, the upper attachment bolt, nut, and cotter pin assembly used to mount the left MLG uplock assembly to the structure were installed but did not engage the uplock assembly, which allowed the uplock assembly to pivot about the lower bolt. Because the upper attachment bolt did not engage the uplock assembly, the left MLG remained in the up-and-locked position and did not respond to the pilot's commands to lower prior to landing.



**Figure.** MLG uplock assembly and upper and lower attachment bolts.

<sup>5</sup> Further, no inspection or sign-off of the mechanic's work was required.

<sup>6</sup> The mechanic who replaced the right uplock assembly stated to investigators that it was his first time replacing an uplock assembly on a Bombardier CRJ.

The NTSB's investigation revealed that AWAC did not offer formal training or OJT specific to the uplock assembly removal and installation procedure. According to the AWAC GMM Volume 1, Chapter 2, personnel who perform maintenance, preventive maintenance, and RII tasks will be trained in accordance with the training program described in the Maintenance Training Program manual, which provides comprehensive training information for AWAC mechanics, technicians, inspectors, and other employees. The curricula in the training manual and modules covered are intended to ensure that maintenance personnel are qualified for operations under 14 CFR 121.375. However, neither the training manual nor the GMM specifies when this training must be completed and what operational limitations exist for mechanics who have yet to complete training.<sup>7</sup> For example, even if a mechanic has not completed the 32 OJT tasks, the mechanic may still perform maintenance tasks without limitations or restrictions. No formal supervision process exists, but mechanics are encouraged to request guidance from a more experienced mechanic if performing a task for the first time.

The NTSB concludes that the AWAC incident mechanic was not properly trained or supervised when he replaced the uplock assembly on the incident airplane for the first time, which led to the error in installation. Further, the error was not detected by the inspector. The NTSB is concerned that the Federal Aviation Administration (FAA) does not currently require mechanics to receive OJT or be supervised while performing RII tasks for the first time.

Problems with untrained or unsupervised mechanics performing maintenance tasks for the first time have also been found at other Part 121 carriers. For example, the NTSB's investigation of the January 8, 2003, accident involving Air Midwest (doing business as US Airways Express) flight 5481, which crashed shortly after takeoff from runway 18R at Charlotte-Douglas International Airport, Charlotte, North Carolina,<sup>8</sup> revealed that, on January 6 and 7, 2003, the accident airplane underwent a detail six maintenance check.<sup>9</sup> One of the mechanics assigned to check the elevator control cable tension was receiving OJT under the supervision of a quality assurance inspector<sup>10</sup> who failed to adequately supervise and direct the mechanic.<sup>11</sup> The accident mechanic had previous control rigging experience, but this was his first time completing the check of the elevator control cable tension on the Raytheon Beechcraft 1900D. The NTSB determined that the probable cause of this accident was the loss of pitch control during takeoff resulting from the incorrect rigging of the elevator control system compounded by the airplane's aft center of gravity, which was substantially aft of the certified aft limit.

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<sup>7</sup> The manual also does not specify that supervision, inspection, or sign-off of the new mechanic's work is required.

<sup>8</sup> *Loss of Pitch Control During Takeoff, Air Midwest Flight 5481, Raytheon (Beechcraft) 1900D, N233YV, Charlotte, North Carolina, January 8, 2003*, Aircraft Accident Report NTSB/AAR-04/01 (Washington, DC: National Transportation Safety Board, 2004).

<sup>9</sup> The detail six maintenance check comprised an elevator check, a rudder check, and a trim tab check.

<sup>10</sup> The quality assurance inspector was in charge of inspecting RIIs.

<sup>11</sup> The NTSB's investigation revealed that the quality assurance inspector should have described the components of the elevator control system to the mechanic, explained the steps in the rigging procedure, demonstrated the critical steps, insisted that all steps needed to be accomplished, and observed the mechanic while he examined the elevator control cable tensions and performed the rigging work. The quality assurance inspector provided OJT and signed off on the mechanic's work.

In addition, the NTSB's investigation of the July 13, 2003, accident involving a Cessna 402C operated by Air Sunshine, Inc. (doing business as Tropical Aviation Services, Inc.),<sup>12</sup> revealed that the differential compression checks<sup>13</sup> performed on the right engine, which failed in flight, were completed by an unsupervised and unassisted<sup>14</sup> assistant mechanic about a month before the accident. The mechanic did not have an airframe and powerplant certificate, had not completed OJT, and had not conducted a compression check prior to conducting the check on the accident airplane.

The NTSB concludes that if the mechanics in the incident and accidents described above had received OJT or adequate supervision while performing the tasks for the first time, their errors might have been recognized and corrected, either by the mechanic or by the person providing the OJT or supervision. Therefore, the NTSB recommends that the FAA require that mechanics performing RII and other critical tasks receive OJT or supervision when completing the maintenance task until the mechanic demonstrates proficiency in the task.

As a result of the Charlotte, North Carolina, accident, the NTSB issued Safety Recommendations A-04-11 and -15, which asked the FAA to do the following:

Develop detailed on-the-job (OJT) training requirements for 14 *Code of Federal Regulations* (CFR) Part 121 air carriers that rely on OJT as a maintenance training method. These requirements should include, but not be limited to, best practices, procedures, and methods for accomplishment and administration of this training. Ensure that these OJT requirements are incorporated into 14 CFR Part 121 air carrier maintenance training programs. (A-04-11)

Require that all 14 *Code of Federal Regulations* Part 121 air carrier maintenance training programs be approved. (A-04-15)

On June 18, 2004, the FAA indicated that it would develop guidance material in response to these recommendations by October 2007. On October 12, 2005, the NTSB indicated that, pending the revision of 14 CFR 121.375, Safety Recommendations A-04-11 and -15 were classified "Open—Acceptable Response." On October 26, 2009, the FAA stated that it intended to address these safety recommendations via rulemaking for Part 121 air carrier maintenance organizations and Part 145 repair stations. The FAA indicated that this rulemaking will implement an OJT training program that will include best practices, procedures, methods for accomplishment, and administration of training. Although the NTSB welcomes this planned rulemaking, there has been little progress on these recommendations in the 6 years since they were issued. The NTSB notes that the AWAC incident reinforces the need for clear OJT requirements for those Part 121 carriers that rely on OJT as a maintenance training method and for the FAA to review and approve air carrier maintenance training programs. In the AWAC incident, the maintenance training program was accepted by the FAA. However, the FAA did not have the authority to approve the program. If the FAA had had the authority to approve AWAC's

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<sup>12</sup> *In-Flight Engine Failure and Subsequent Ditching, Air Sunshine, Inc., Flight 527, Cessna 402C, N314AB, About 7.35 Nautical Miles West-Northwest of Treasure Cay Airport, Great Abaco Island, Bahamas, July 13, 2003*, Aircraft Accident Report NTSB/AAR-04/03 (Washington, DC: National Transportation Safety Board, 2004).

<sup>13</sup> Differential compression checks are designated RIIs.

<sup>14</sup> Air Sunshine's Maintenance Manual indicated that two people should conduct the compression checks.

maintenance training program, some of the unacceptable training practices may have been detected. Therefore, the NTSB reiterates Safety Recommendations A-04-11 and -15 and classifies both “Open—Unacceptable Response.”

Also as a result of the Charlotte, North Carolina, accident, the NTSB issued Safety Recommendation A-04-16, which asked the FAA to do the following:

Require that 14 *Code of Federal Regulations* Part 121 air carriers implement comprehensive human factors programs to reduce the likelihood of human error in aviation maintenance. (A-04-16)

On June 18, 2004, the FAA stated that it would issue guidance on human factors training. However, in its October 12, 2005, response, the NTSB indicated that it was concerned that the FAA did not understand the intent of the recommendation, which was to add a comprehensive human factors program to aviation maintenance programs. The NTSB noted that human factors considerations are not just confined to training and that a program limited to training will not satisfy the intent of this recommendation. Safety Recommendation A-04-16 was classified “Open—Unacceptable Response.” On October 26, 2009, the FAA indicated that the planned rulemaking for Part 121 air carrier maintenance organizations and Part 145 repair stations would also address human factors issues in these programs. The FAA stated that, to address this recommendation until the rulemaking was completed, it issued guidance material in October 2005 on human factors in aviation maintenance, co-sponsored four aviation maintenance human factors symposia, and developed and distributed to the aviation industry guidance material on human factors considerations and training for aviation maintenance operations.

The investigation of the AWAC incident revealed that AWAC offered a human factors training program for new hires that consisted of an 8-hour PowerPoint presentation covering a wide range of topics, including communication, fatigue, and shift turnovers. The NTSB’s investigation revealed that some of the topics did not relate specifically to maintenance human factors issues, and the exercises did not necessarily correlate to real-world experiences that mechanics might face. The presentation provided knowledge of human factors issues but did not encourage skill development of how to prevent human factors events. For example, the training would have been more useful if it had discussed the challenges faced when working in a confined space with limited lighting and the importance of using a flashlight and mirror to ensure tasks are completed successfully. As part of implementing Safety Recommendation A-04-16, the FAA should provide guidance on what topics, specifically, to include in human factors training. The NTSB concludes that the guidance material produced and distributed by the FAA did not provide sufficiently detailed information to use in creating an acceptable maintenance human factors program or to be used by an FAA inspector to review such a program if it were required. Safety Recommendation A-04-16 was issued almost 6 years ago, and the FAA has not yet adequately addressed this recommendation. Therefore, the NTSB reiterates Safety Recommendation A-04-16. (Safety Recommendation A-04-16 remains classified “Open—Unacceptable Response.”)

## Training of Inspectors

According to the GMM, Volume 1, Chapter 10-2, AWAC required its RII inspectors to hold an FAA airframe and/or powerplant license, an FAA repairman's certificate, and a Transport Canada Aircraft Maintenance Engineer License with appropriate endorsement for the equipment being maintained. AWAC personnel also must have satisfactorily completed training on the equipment being inspected, in which AWAC provides a basic review of the RIIs and indicates that they should be visually inspected.

In the AWAC incident, the RII inspector on duty stated in a postincident interview that he had never inspected an uplock assembly and did not recall if he had ever replaced one as a mechanic but that he referred to the AWAC Aircraft Maintenance Manual (AMM) during the inspection.<sup>15</sup> The RII inspector further indicated that he used a flashlight during the visual inspection and that he had "kind of a blind view with the mount bolts." He stated that he recognized three discrepancies<sup>16</sup> on the left uplock assembly that needed to be corrected and verbally instructed a mechanic to correct the items but failed to update the maintenance logs as required. In addition, the incident inspector stated to investigators that he performed the functional gear check from the cockpit of the airplane and that, although he could not actually see the gear in motion from his position, he was watching the engine indicating and crew alerting system indication, which verified a "good swing."<sup>17</sup> He stated that the only part of the manual extend procedure that he completed was to manually move the uplocks into the locked and unlocked position by hand. (Doing so would show the mechanic what the uplocks look like when they are in the locked position.) The RII inspector did not perform a complete operational test as required.

The RII inspector stated to NTSB investigators that he did not receive any training, formal or informal, regarding the removal, installation, and inspection procedures specific to an uplock assembly. The NTSB's review of AWAC's RII inspector training materials determined that training on uplock assemblies was minimal, indicating that inspectors only had to visually inspect the installation. Inspectors were not required to inspect an uplock assembly during the training process. At the time of the incident, the materials did not indicate that inspectors should use a headlamp or mirror during the inspection.<sup>18</sup>

The NTSB concludes that the post-maintenance inspections performed by the AWAC incident RII inspector were not adequate to detect the misrigging of the uplock assembly. The incident inspector's lack of training and experience with the removal and installation procedures of the uplock assemblies may have contributed to his failure to detect installation discrepancies. In addition to the inspector's lack of experience, he failed to follow the procedures in the AMM.

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<sup>15</sup> AWAC AMM Task 32-32-05-400-801, "Installation of the MLG Uplock Assembly," provides mechanics and RII inspectors with detailed instructions for installing and inspecting uplock assemblies and specifically instructs inspectors and mechanics to perform "a functional test of the extension and retraction system" and "an operational test of the manual release system of the landing gear."

<sup>16</sup> The discrepancies were to replace the lower cotter pin, fix a gap measurement, and fix a hydraulic fluid leak. (The upper bolt, nut, and cotter pin assembly did not engage the uplock assembly.)

<sup>17</sup> A good swing means that the gear came down properly and that the indications in the cockpit match the gear position.

<sup>18</sup> Bombardier has recently revised the procedures in the AMM to indicate that inspectors should use a flashlight and mirror.

The NTSB concludes that if the incident inspector had followed the RII inspection procedures and the manual extend of the gear had been accomplished on the incident airplane, he would have likely detected the misrigging of the uplock assembly and thus prevented the incident. Therefore, the NTSB recommends that the FAA require that RII inspectors receive supervision or OJT on the proper inspection of RII items until the inspector demonstrates proficiency in inspection.

Therefore, the National Transportation Safety Board recommends that the Federal Aviation Administration:

Require that mechanics performing required inspection item and other critical tasks receive on-the-job training or supervision when completing the maintenance task until the mechanic demonstrates proficiency in the task. (A-10-96)

Require that required inspection item (RII) inspectors receive supervision or on-the-job training on the proper inspection of RII items until the inspector demonstrates proficiency in inspection. (A-10-97)

In addition, the National Transportation Safety Board reiterates the following recommendations to the Federal Aviation Administration and reclassifies them “Open—Unacceptable Response”:

Develop detailed on-the-job (OJT) training requirements for 14 *Code of Federal Regulations* (CFR) Part 121 air carriers that rely on OJT as a maintenance training method. These requirements should include, but not be limited to, best practices, procedures, and methods for accomplishment and administration of this training. Ensure that these OJT requirements are incorporated into 14 CFR Part 121 air carrier maintenance training programs. (A-04-11)

Require that all 14 *Code of Federal Regulations* Part 121 air carrier maintenance training programs be approved. (A-04-15)

In addition, the National Transportation Safety Board reiterates the following recommendation to the Federal Aviation Administration:

Require that 14 *Code of Federal Regulations* Part 121 air carriers implement comprehensive human factors programs to reduce the likelihood of human error in aviation maintenance. (A-04-16)

In response to the recommendations in this letter, please refer to Safety Recommendations A-10-96 and -97, and A-04-11, -15, and -16. If you would like to submit your response electronically rather than in hard copy, you may send it to the following e-mail address: [correspondence@ntsb.gov](mailto:correspondence@ntsb.gov). If your response includes attachments that exceed 5 megabytes, please e-mail us asking for instructions on how to use our secure mailbox. To avoid confusion, please use only one method of submission (that is, do not submit both an electronic copy and a hard copy of the same response letter).

*[Original Signed]*

By: Deborah A.P. Hersman  
Chairman