NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

November 30, 2015

AIRWORTHINESS

Group Chairman's Factual Report

ERA14MA060

A. ACCIDENT: ERA14MA060

Operator:	IBC Airways, flight 405
Location:	La Alianza, Puerto Rico
Date:	December 2, 2013
Time:	2010 Atlantic Standard Time
Aircraft:	Fairchild SA227-AC
Registration Number:	N831BC

B. AIRWORTHINESS GROUP

Chairman: Clinton R. Crookshanks
National Transportation Safety Board
Denver, Colorado

Member: Andrew McAnaul
Federal Aviation Administration
San Antonio, Texas

Member: James Norton
M7 Aerospace, LLC
San Antonio, Texas

Member: William Womick (replaced by Hans Johnsson 2/15)
IBC Airways
Fort Lauderdale, Florida

Member: James McClean
Worldwide Aircraft Services
Springfield, Missouri

C. SUMMARY

On December 2, 2013, at 2010 Atlantic standard time, a Fairchild SA227AC, N831BC, operating as IBC Airways flight 405 ("Chasqui 405"), was destroyed during a rapid descent to terrain near La Alianza, Puerto Rico. The captain and the first officer were fatally injured. Night visual meteorological conditions prevailed. The international cargo flight was operating on an instrument flight rules flight plan between Las Americas International Airport (MDSD), Santo Domingo, Dominican Republic, and San Juan International Airport (TJSJ), San Juan, Puerto Rico, under the provisions of 14 Code of Federal Regulations Part 135.

D. DETAILS OF THE INVESTIGATION

1.0 Aircraft

The Fairchild SA-227AC Metro is a twin engine, propeller driven, low wing, pressurized airplane (Figure 1[1]) originally equipped to carry 19 passengers. The airplane is of all metal construction, has a cruciform tail and is equipped with a retractable tricycle landing gear system. The airplane is powered by two Garrett TPE-331 engines and has a maximum takeoff weight of 16,000 pounds. The airplane is 59.35 feet long, has a wingspan of 57 feet and a tail height of 16.66 feet. The accident airplane was configured to carry only cargo. A photo of the accident airplane is shown in Figure 2.

The Metro fuselage is a typical semi-monocoque structure composed primarily of aluminum alloy frames, skins, stringers, and bulkheads. Locations longitudinally along the fuselage are denoted by fuselage stations (FS) measured in inches from the datum (FS 0.000) located at the forward bulkhead, Figure 3. The fuselage is divided into 3 major sections that join together at production splices. The forebody structure extends from FS 0.000 to FS 126.060 and includes the cockpit. The constant section structure extends from FS 126.060 to FS 493.247 and includes the entry door, emergency exits, passenger windows, cargo door and the wing attach points. The aftbody structure extends from FS 493.247 to FS 659.975 and includes the attach points for the vertical stabilizer. The radome is installed on the bulkhead at FS 0.000 and extends forward to FS -28.940. The fuselage is pressurized between the forward pressure bulkhead at FS 69.310 and the aft pressure bulkhead at FS 631.310. The wing is attached to the lower portion of the fuselage at four points, 2 on the main spar and 2 on the rear spar. The main spar attach fittings are sandwiched between fuselage frames at FS 272.271 and FS 275.885. The rear spar attach fittings are sandwiched between fuselage frames at FS 308.423 and FS 311.041.

The SA-227AC wing is a twin-spar arrangement with integral fuel tanks and removable flaps and ailerons. Locations along the span are denoted by wing stations (WS) measured in inches from the datum (WS 0.000) at the centerline of the airplane, Figure 4. The wing is of a one-piece design with continuous main and rear spars from WS 266.000 LH to WS 266.000 RH. The spars are built-up I-beam structures constructed of aluminum alloy with titanium alloy and steel alloy reinforcements on the upper and lower spar caps. The wing attach fittings on both the main and rear spars are located at WS 27.103 RH and LH. The height of both the main and rear spars decreases between WS 27.103 and WS 8.540 where the spars pass under the fuselage. The main spar transitions from about 13 inches tall to about 9 inches tall and the rear spar transitions from about 10 inches tall to about 9 inches tall. Five-foot wing extensions are attached to the outboard end of each wing to increase the span to 57 feet. The ailerons are installed along the trailing edge between WS 172.100 and WS 266.000 (RH and LH) and the flaps are installed along the trailing edge between WS 29.428 and WS 172.100 (RH and LH).

The airplane is equipped with conventional horizontal and vertical stabilizers composed primarily of aluminum alloy components in a cruciform arrangement. The vertical stabilizer is a cantilever design with two spars that are attached to bulkheads in the aft fuselage. A cable driven rudder and trim tab are attached to the aft spar of the vertical stabilizer. The horizontal stabilizers

[1] All Figures are presented in Appendix A to this report.

are of cantilever design that are fastened together at the fuselage centerline and attached to the vertical stabilizer with a trunnion bolt. The stabilizer pivots around the trunnion bolt changing the angle of incidence of the stabilizer and providing pitch trim for the airplane. The pitch trim is controlled electrically by switches on the control yokes that actuate two motor operated jackscrews mounted to the top of the fuselage. All aluminum cable driven elevators are attached to the horizontal stabilizers and fastened together at the center splice plate hinge point.

The ailerons, elevators, and rudder are manually controlled from either the pilot or copilot station in the cockpit by a conventional yoke and rudder pedals. Aileron control cables, 1/8 inch in diameter, interconnect the yokes and run through several pulleys aft under the floor to an aileron drum in the center wing area. The aileron drum is connected to a series of push-pull tubes that run along the aft side of the rear spar on each wing to bellcranks mounted near the aileron inboard hinges. Push-pull tubes connect the ailerons to the bellcranks for aileron control. Elevator control cables, 1/8 inch in diameter, run from the elevator walking beam immediately aft of the columns through several pulleys aft under the floor to the elevator quadrant in the vertical stabilizer. Push-pull tubes connect the elevators to the quadrant for elevator control. Rudder cables, 1/8 inch in diameter, run through several pulleys aft under the floor to the rudder bellcrank in the aft fuselage. The rudder bellcrank drives the rudder torque tube for rudder control. Aileron and rudder trim are controlled by control wheels on the center pedestal in the cockpit. The aileron and rudder trim cables, 1/16 inch in diameter, run through several pulleys to their respective tabs. Elevator trim is controlled electrically as described earlier. The flaps are electrically controlled and hydraulically actuated.

2.0 Accident Aircraft Examination

Manufacturer's Serial Number (MSN): AC-654B
Total Time: 33,844.5 hours (prior to flights on 12/2/13)
Total Cycles: 35,698 cycles (prior to flights on 12/2/13)

The wreckage was recovered and shipped to a warehouse facility at the Port of Houston. The group examined the wreckage February 4-6, 2014.

The wings separated from the airplane during the accident sequence. The right wing was mostly complete from the centerline of the airplane (WS 0) to the wing tip. The main spar upper cap members were fractured between about WS 2 and WS 6. The main spar lower cap members all fractured near WS 9. The rear spar upper cap members fractured between about WS 0 and WS 3 and the rear spar lower cap members all fractured near WS 0. The upper cap members on both the main and rear spars exhibited upward deformation and curling at the fracture locations. The upper-most spar cap members on both the main and rear spars were separated at the rivet line and deformed in an upward curl. The lower cap members on both the main and rear spars did not have any noticeable deformation. There was light blue paint transfer on the upper surface of the right wing between about WS 32 and WS 81. The right flap remained attached to the wing and was free to move. The inboard half of the right aileron remained attached to the wing between the inboard edge and the center hinge point. The outboard half was not recovered. The outboard aileron hinge was intact on the right wing and included the hinge clevis from the right aileron. The hinge clevis was pulled from the right aileron with the attachment bolts intact. There was a

small piece of torn aileron structure remaining at the lower attach bolt with fracture features consistent with overstress separation. Control continuity was established in the push-pull tubes from the aileron to the rear spar fracture location. The right aileron trim tab remained attached to the right aileron and control continuity was established from the tab to the wing fracture location at the rear spar. The right aileron trim tab actuator was dislodged from its mount and appeared to be fully retracted. The chain was not installed on the sprocket of the actuator but was found adjacent to the actuator. The right main landing gear remained attached to the wing in the down position, however, photos show the landing gear was in the extended position at the impact sight. The down locks were intact and engaged. The up lock was intact with no abnormal damage. The drag brace was fractured between the trunnions. The right engine was recovered separated from the wing and fractured at the Keelson beam interface with the wing. There was light blue paint transfer on the inboard side of the right engine nacelle.

The left wing was mostly complete from WS 0 to the outboard end of the flap at WS 174 with significantly more damage than the right wing. The spar fractures at the inboard end matched the fractures on the right wing. The upper cap members on both the main and rear spars exhibited upward deformation and curling at the fracture locations. The lower cap members on both the forward and aft spars did not have any noticeable deformation. Both spars and the structure between them were deformed forward between the fracture locations and about WS 27. There was dirt and rocks embedded in the structure at the fracture location. A large section of the outboard left wing from about WS 174 to WS 337 was recovered separately. The fiberglass wing tip was not attached to this section. Additionally, two smaller pieces of wing skin structure from the area of the break were recovered separately. There was significant impact damage, scratching, and scoring on the lower wing surface at the location of the break. The outboard 18 inches of the left aileron with the balance weight attached was recovered separately from the wing with mechanical damage at the outboard hinge location. The remainder of the left aileron was not recovered. The outboard aileron hinge was intact on the left wing and included the hinge clevis from the left aileron. The hinge clevis was pulled from the left aileron and the attachment bolts were not present. The fracture features on the outboard left aileron at the outboard hinge location were consistent with overstress separation. Aileron control continuity was established from the wing break at WS 174 to the rear spar fracture location. The left aileron trim tab actuator appeared to be in the fully extended position. There was a small section of aileron trim cable lodged in a pulley at the wing root. The aileron trim cable was missing from the trim actuator to the wing root and not recovered. The guides, pulleys, and fair leads for the left aileron trim cable appeared undamaged. The left flap remained attached to the wing but could not be moved due to the damage. There was some light blue paint transfer on the upper surface of the flap from about WS 50 to WS 68. The left main landing gear remained attached to the wing in the up position. The inboard side of the wheel well was deformed inboard such that the inboard drag brace trunnion was not fully engaged. The landing gear could be extended by hand but would not engage the down locks due to the deformation at the drag brace trunnion. The up and down locks were intact with no abnormal damage. The left engine was recovered separated from the wing and fractured at the Keelson beam interface with the wing.

The aft fuselage was mostly complete from the forward edge of the cargo door at FS 438 to the end of the tail cone but sustained some crushing damage laterally. The vertical stabilizer, rudder and right horizontal stabilizer were reportedly attached to the aft fuselage at the wreckage site

but were cut from the fuselage for transport. There was a distinct impact impression with paint and metal smearing on the right side of the fuselage from FS 438 to FS 474 that was about 4 feet high. The pitch trim actuator remained installed at the base of the vertical stabilizer but sustained several areas of damage from the cutting of the structure during recovery. The two actuator rods were cut from the actuator during recovery but remained attached to the horizontal stabilizer fittings at the upper end. The two fittings were fractured from the horizontal stabilizer. Several flight control cables extended from the forward end of the aft fuselage. All of the cable lengths were measured from the forward edge of the cargo door forward. The rudder control cables were identified and continuity was established to the rudder control horn at the base of the vertical stabilizer. The rudder cables extended 22.5 and 25 feet. The gust lock cables were still attached to the gust lock and extended 5 feet, 2 inches and 11 feet, 10 inches forward. The rudder trim cables were cut when the stabilizer was removed. They were removed and measured 30 feet, 4 inches and 16 feet, 9 inches. The elevator control cables were cut when the stabilizer was removed. They were removed and measured 36 feet, 9 inches and 44 feet, 6 inches. All of the forward fractured ends of the cables exhibited a splayed appearance consistent with overstress separation.

The vertical stabilizer, rudder and right horizontal stabilizer were mostly complete and cut from the aft fuselage during recovery. The aft ends of the elevator cables remained attached to the quadrant in the vertical stabilizer. The right horizontal stabilizer was folded up against the vertical stabilizer. There was dark blue paint transfer on the upper surface of the right horizontal stabilizer. The right elevator was separated from the stabilizer and recovered mostly complete. The tip and counterweight were separated and not recovered. The rudder counterweight was separated and not recovered. The left horizontal stabilizer was recovered separated at the impact site near the aft fuselage. The inboard 21 inches of left horizontal stabilizer forward spar and 18 inches of aft spar remained attached to the vertical stabilizer. Both spars exhibited upward deformation at the outboard ends where they were fractured. The left horizontal stabilizer had dark blue paint transfer on the upper surface. Two pieces of the left elevator were recovered. The inboard piece spanned from the control horn at the inboard end out about 42 inches. The outboard piece was about 22 inches long and contained the elevator counterweight. The center portion of the left elevator was not recovered.

The forebody section including the cockpit was mostly complete from the forward bulkhead at FS 0 aft to FS 126 but sustained heavy crushing damage. This section contained the cockpit floor, center pedestal, control columns, rudder pedals, both forward baggage door cutouts, and the nose landing gear. The nose landing gear was reportedly partially extended at the wreckage site and fully extended during the examination. The drag brace trunnions had been pulled out and both the up and down locks were intact with no obvious damage. There was a distinct tire impression on the forward exterior surface of the right nose landing gear door. A portion of the outer bead area on the right nose wheel was fractured and separated. The upper forebody skin and pilot compartment windows were separated and recovered in the debris field. Control continuity was established from the control columns and rudder pedals through the floor to the aft end of the section. The control yokes were disassembled to assess the condition of the aileron sprockets and chains at the upper end of the yokes. The sprockets and chains were intact and had no evidence of binding. The flap handle was lodged in place between 0 and ¼ due to the deformation of the control stand.

The center portion of the fuselage was reconstructed in the hangar (Figures 5 and 6). Most of the upper fuselage structure was conclusively identified from the forward end of the pilot compartment windows at FS 69 to the aft cargo door at FS 438. There was an area of structure from the right side of the fuselage where the "IBC" logo was painted that was not recovered between about FS 160 and FS 250. There was a distinct cut through the fuselage near FS 165 (about 5 inches aft of the main entry door) that ran from the lower edge of the entry door on the left side to the top of the stripe on the right side. See the green strap in figure 5. The edges of the cut exhibited mechanical damage, paint and metal smearing, and multi-directional curling and folding of the structure that was markedly different from the tearing of the skin and structure evident elsewhere.

3.0 Tests and Research

Pitch Trim Setting

The pitch trim actuator was removed from the aft fuselage section for further examination (Figure 7) by cutting the lower fixed rod ends. There was some cutting damage to the actuator body caused during removal of the vertical stabilizer at the accident site for recovery as annotated by the red arrow in Figure 7. The green arrow in Figure 7 shows where the lower fixed rod ends were cut from the actuator body during the exam. Both of the actuator rods were also cut during the recovery as annotated by the yellow arrows in Figure 7. Prior to removal of the actuator from the wreckage, the cut ends of the actuator rods were placed adjacent to each other and the distance between the center of lower fixed rod ends and the center of the upper rod ends on the actuator rods was measured to be 19.125 inches. The saw cuts in the actuator body measured about 0.125 inches wide. Based on these measurements, it was determined that the extension of the pitch trim actuator was about 19.25 inches at the time of the breakup. The length of the actuator between the centers of the rod ends should have been 20.25 inches in the fully extended position and 13.79 inches in the fully retracted position based on the installation drawing. The aircraft maintenance manual provides for the rigging of the horizontal stabilizer to a leading edge up position of 2.20º-2.60º and a leading edge down position of 7.60º-8.00º to account for variations in manufacture and tolerances. Since the actuator was linear, the measurement could be interpolated to determine the stabilizer incidence at an extension of 19.25 inches, yielding an incidence of 0.62º-1.02º leading edge up (airplane nose down trim).

The load sheet for the accident flight[2] showed that the airplane had a gross takeoff weight of 13,215 pounds with a center of gravity (CG) location at 264.9 inches and a planned landing weight of 12,415 pounds with a CG location at 263.2 inches. The CG limits for the airplane were listed as 259.2 inches to 277.0 inches. In trimmed cruise flight with a reasonably centered CG location similar to the accident flight, the horizontal stabilizer would typically be set somewhere in the range measured on the recovered actuator (0.62º-1.02º leading edge up). This setting would correspond to a trim actuator length of about 19.25 inches as detailed above. In a typical initial descent the airplane would be trimmed to a slightly more nose down position but still within the tolerance range for the length measured on the recovered actuator.

[2] See Attachment 1 to this report.

Pitch Trim Actuator Teardown

The P/N DL5040M6 linear electro-mechanical actuator was originally manufactured by Simmonds Precision and last overhauled by L-3 Communications Component Overhaul and Repair, Inc., in Fort Lauderdale, Florida. The actuator was taken to L-3 for a detailed examination and tear down under NTSB supervision. The actuator was S/N F1207 and the modification sticker showed no modifications had been incorporated in accordance with the current status of this particular actuator. Both of the actuator tubes were cut and separated from the actuator during recovery. There were saw cuts on the left, right, and aft sides of the actuator housing. The sealant was removed from around the brake housing cover on the bottom of the unit and the cover was removed. The brake was in the locked position. The stop nuts were removed from the upper ends of the nut tubes and the housing was removed. The right nut tube and internal jackscrew were cut through at the lower end. Power was applied to the brake circuit to release the brake. There was gear continuity from the brake to both motors. There was some rust in the brake assembly characterized as "normal" by L-3. Other than the cutting dust and debris, the unit appeared clean. The right and left actuator motors were removed. The left motor turned with little resistance. The right motor turned with some roughness, one spot per revolution required more turning force. The right motor was P/N DM1845M4, S/N F1212, and the armature measured 10 mm. The left motor was P/N DM1845M4, S/N F1213, and the armature measured 12 mm. The clutches were disassembled. The gears appeared normal and had normal wear. The nut tubes were removed and had minimal rust in the bearing areas. The jack screws would not turn due to the cutting damage. The gear train was disassembled with no evidence of broken or worn gear teeth. The right jackscrew was disassembled and was free to rotate with no evidence of binding. The left jackscrew was disassembled and was free to rotate with no evidence of binding.

Right Motor (co-pilot's side) – The brushes appeared normal with wear consistent with the age of the unit. The upper bearing appeared normal with no roughness. The lower bearing appeared normal with no roughness. The motor was disassembled and had evidence of normal wear.

Left Motor (pilot's side) – The brushes appeared normal with noticeably more wear than the right motor. The upper bearing appeared normal with no roughness. The lower bearing appeared normal with no roughness. The motor was disassembled and had evidence of normal wear with significantly more carbon dust and debris than the right.

Aileron Controls

On September 4, 2014, M7 Aerospace issued two service bulletins instructing operators to inspect the aileron bellcranks, link rods, hinge brackets, and rod end bearings for damage and tightness and on September 19, 2014, M7 Aerospace issued a revised service bulletin instructing operators to inspect the outboard aileron hinge attachments for cracking[3]. The left and right aileron bellcranks and attached link rods were retrieved from the wreckage for examination.

The left aileron bellcrank was recovered separated from the left wing but with the aileron link rod and a control tube attached. The bellcrank pivot bolt and both rod end bolts were installed with the cotter pins intact. There was some wood debris embedded in the head of the cotter pin on the control tube attachment bolt. There was also some mechanical damage on the upper and

[3] See Attachment 2 to this report for the service bulletins.

lower surfaces of the bellcrank adjacent to the pivot bolt. The control tube was removed to facilitate shipping of the bellcrank. The control tube rod end bearing moved freely. The retained left aileron bellcrank and attached aileron link rod are shown in Figure 8. The threaded portion of the male rod end on the aileron link rod was deformed and the banjo body on the female rod end (normally attached to the aileron) was fractured and deformed. The spherical bearing from the female rod end was not recovered. The fracture faces on the banjo body were examined under a microscope and had features consistent with overstress separation. The bolt attaching the aileron link rod male rod end was disassembled. The male rod end was examined under a microscope and no evidence of cracking was observed in the banjo body. The spherical bearing on the male rod end was clean and free to rotate with no binding evident.

The right aileron bellcrank remained attached to the right wing at its mounting location. The control tube and aileron link rod were attached and the aileron link rod was attached to the right aileron portion that remained. The bellcrank pivot bolt and both rod end bolts were installed with the cotter pins intact. The control tube bolt, pivot bolt, and aileron attach bolt were disassembled in order to remove the bell crank and aileron link rod. The control tube rod end bearing moved freely. The retained right aileron bellcrank and attached aileron link rod are shown in Figure 9. The threaded portion of the male rod end on the aileron link rod was deformed. The bolt attaching the aileron link rod male rod end was disassembled. The male and female rod ends were examined under a microscope and no evidence of cracking was observed in the banjo bodies. The spherical bearing on the male rod end was dirty and able to rotate with some binding. The spherical bearing on the female rod end was seized.