DATA SUMMARY

LOCATION

Date and time	**Tuesday, 10 March 2007; 11:42 UTC[1]**
Site	**Casarrubios del Monte Aerodrome (Toledo)**

AIRCRAFT

Registration	**N1271B**
Type and model	**COLUMBIA 350**
Operator	**Private**

Engines

Type and model	**TELEDYNE CONTINENTAL MOTORS (TCM) IO-550-N**
Number	**1**

CREW

Pilot in command

Age	**41 years old**
Licence	**Private Pilot License (PPL(A))**
Total flight hours	**693.55 h**
Flight hours on the type	**29.7 h**

INJURIES

	Fatal	Serious	Minor/None
Crew			**1**
Passengers			
Third persons			

DAMAGE

Aircraft	**Substancial**
Third parties	**None**

FLIGHT DATA

Operation	**General aviation – Private**
Phase of flight	**Landing roll**

REPORT

Date of approval	**27th January 2010**

[1] Unless otherwise noted, the reference time in this report is UTC. To obtain local time, add 1 hour to UTC.

1. FACTUAL INFORMATION

1.1. Description of event

On 10 March 2007, a Columbia 350 aircraft (now Cessna 350), registration N1271B, was flying from the Cuatro Vientos Airport (LECU) to the Casarrubios Aerodrome (LEMT). Only the pilot was onboard. Some 15 minutes after takeoff, at around 11:42, the pilot proceeded to land at the destination aerodrome. During the landing roll, once all three wheels were on the ground and the pilot started to apply the brakes, the aircraft turned sharply to the right, as stated by the pilot, who then corrected with the left foot, after which the aircraft started to veer left, after which the pilot applied a correction in the opposite direction. The aircraft started to vibrate violently. The pilot applied differential braking to offset the aircraft's turns, but the vibrations did not cease until the airplane came to a complete stop nearly at the end of the runway.

The pilot was uninjured.

The right gear fairing detached at the end of the run, although once on the stand the pilot noted that, in addition to other damage, the most significant consequence was the presence in the tail of the aircraft of a large crack in the skin along the bottom of the fuselage with deformations that extended diagonally to the top (see Figure 1).

1.2. Personnel information

The pilot had a United States private pilot license (PPL(A)) issued by the Federal Aviation Administration (FAA) and a JAR-FCL license issued by Spanish Civil Aviation Authority

Figure 1. Close-up of the damage evident in the right wheel fairing and in the tail

(DGAC), both of them valid and in force, as well as an FAA class 3 medical certificate and a JAR-FCL class 2 medical certificate, both valid and in force.

As for the flying experience, the pilot had a total of 693.55 flying hours at the time of the incident, of which 29.7 were on the type (10.4 in a simulator). In all, the pilot had performed 24 landings on this same aircraft prior to the incident landing.

The incident took place on the first flight of the day.

1.3. Aircraft information

1.3.1. *General information*

The Cessna 350 aircraft (formerly known as Columbia 350 and, according to the aircraft records, an LC42-550FG model), registration N1271B and S/N 42529, is a single-engine, low-wing, tricycle fixed —landing gear airplane with four seats. It is equipped with a 310-hp TCM engine model IO-550-N (S/N 689121) and a Hartzell propeller model PHC-J3YF-1RF/F7491D1 (S/N FP4647B).

The fuselage has a semi-monocoque structure made of composite materials comprised mostly of outer layers of pre-preg fiberglass around a honeycomb interior. In areas where added structural strength is needed, such as the wing spars, carbon fibers are added to the honeycomb sandwich.

This aircraft is certified according to the requirements of FAR 23, "Airworthiness Standards: Normal, utility, acrobatic and commuter category airplanes."

It had an Airworthiness Certificate for the Utility category issued by the FAA on 30 November 2006, and a United States Registration Certificate issued by the FAA on 22 November 2006. The aircraft had an insurance certificate and an aircraft station license, both of them valid.

The maintenance records show that the first 50-hour inspection was done on 22 February 2007 in Spain with a total of 44.20 real hours. One of the items on this inspection is a check of the air pressure in the tires.

At the time of the incident the aircraft had a total of 50.60 flight hours.

1.3.2. *Tail structure*

The internal structure of the aircraft's tail consists of two main elements:

Antenna bulkhead – The antenna bulkhead is a structural member that provides lateral and torsional shear carry-through. It is bonded to the aft baggage bulkhead, fuselage sides, and vertical shear web.

Vertical shear web – The vertical shear web is the main structural shear web in the vertical stabilizer. It is bonded to the fuselage sides, which form the vertical stabilizer, antenna bulkhead, and NAV bulkhead.

The fracture took place at the juncture of both elements (antenna bulkhead and vertical shear web). See Figure 2.

1.3.3. *Landing gear structure*

The basic structure of the landing gear on this model, according to the Maintenance Manual, is as follows:

Design

The Columbia 350 has a fixed tricycle landing gear configuration. The main gear is constructed of high strength tubular steel and mounted to the fuselage via a welded steel gearbox.

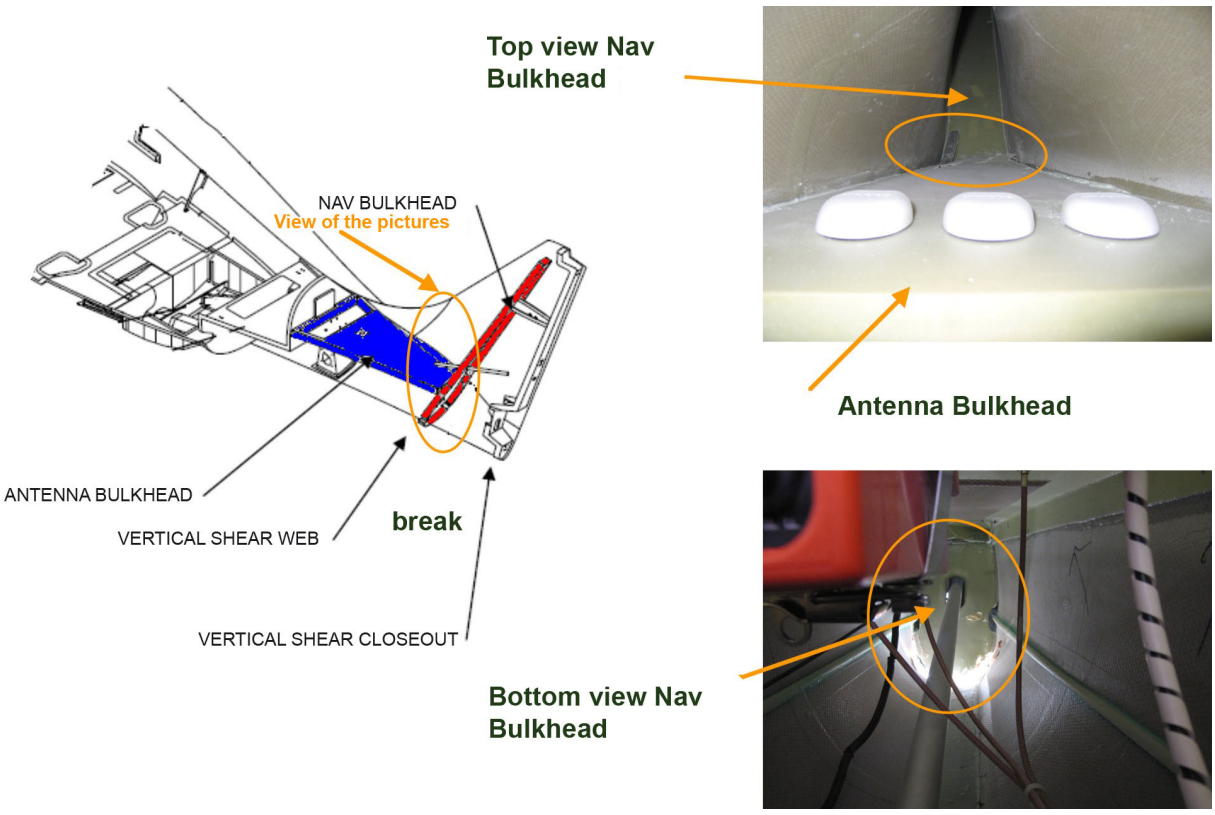

Figure 2. Close-up of tail structure

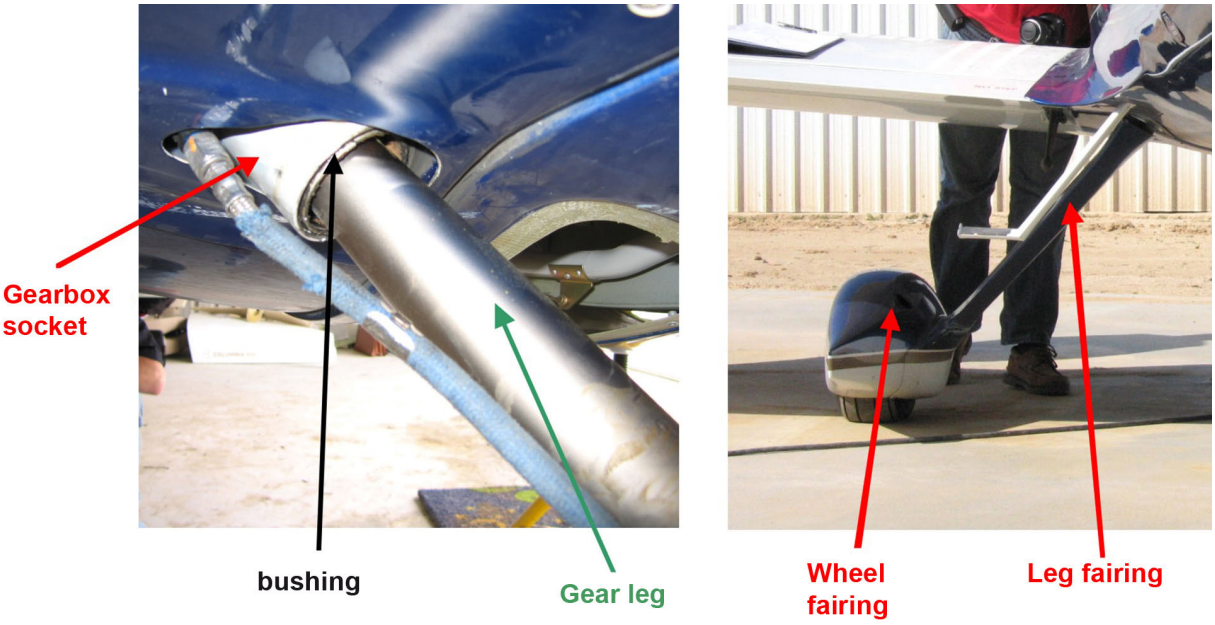

Figure 3. Close-up of gear structure

Between the legs and the gearbox there are two copper alloy bushings with a Teflon-coated inner surface to prevent wear and corrosion of the leg. On the outer surface there is a layer of adhesive that bonds this surface to the inner wall of the gearbox. According to the manufacturer, the main purpose of the bushings is to support non-axial loads on the main landing gear legs. The main landing gear is attached to the fuselage structure via a welded steel gearbox. The aircraft has brakes on the main wheels.

The nose wheel is a free castoring nose wheel. The aircraft is steered via *differential braking* of the main gear brakes, which causes the nose wheel to turn freely.

When mounting the main gear legs, it is important to determine their toe-in/toe-out (θ) and their camber (α).

- Toe-in/toe-out is the angle between the wheel axle and the vertical plane perpendicular to the aircraft's axis of symmetry.
- The camber is the angle between the wheel axis and the horizontal plane perpendicular to the aircraft's axis of symmetry.

These values are established with all the wheels on the ground on a low-friction surface.

The Maintenance Manual specifies the tolerances for the camber and toe-in/toe-out, which must be satisfied with the bushings properly installed.

Service and Maintenance

The gearbox is a major structural component and should be inspected every 100 hours or annually by wear and corrosion. This requires removing the fairings and the gear leg per inspecting the gear leg sockets of the gearbox for wear and corrosion and if surface corrosion is present, lightly hone the interior diameter of the socket using a cylinder bore hone.

The bushing at the lower end of the socket should also be inspected for excessive wear and replaced if required. When the bushing is replaced, the inner surface of the socket has to be carefully cleaned out and covered with Loctite 675[2] retaining compound, which must be allowed to fully cure before the legs are installed.

1.4. Pilot's statement

The pilot stated that on that day he was preparing for a solo flight from Cuatro Vientos to Casarrubios. Atmospheric conditions were CAVOK with a light breeze from the northeast. The onboard fuel tanks were filled almost to half capacity. Upon approaching the destination aerodrome, he performed a normal approach, doing the left downwind, base and final legs for landing on runway 08 at Casarrubios (LEMT). The indicated final speed was 80 kt and he used full flaps. The landing was normal and after putting down all three wheels and starting to brake the aircraft (approximately 100 m after the touchdown point), the aircraft turned sharply to the right and started sliding to the left, resulting in a vibration. According to his statement, he was able to control this initial lurch by applying differential brakes, after which there was another lurch, in the opposite direction, and so on successively three or four additional times, during which the vibration and the rattle became considerable. When the lurches began, he was able to lift the flaps to increase steering effectiveness, but he was not able to adjust the mixture control to stop the engine.

The vibrations stopped when the aircraft lost almost all speed, some 100 m before the end of the runway. He then taxied the aircraft to the exit where, upon stepping on the right brake to turn, the right leg vibrated once more. While taxiing he noted that he had lost one of the wheel fairings, of which he notified traffic on approach.

Then, believing the only damage to be the lost fairing, he taxied to the stand. It was not until he exited the aircraft that he noticed the damaged to the tail.

The pilot also stated that on the flight immediately prior to the incident flight (6 days earlier), after a three-hour flight and while landing at Cuatro Vientos airport (LECU),

[2] According to the Maintenance Manual delivered to the owner with the aircraft.

the aircraft also gave a jolt to the right upon braking and started to vibrate, though the deceleration was normal once the attitude was corrected and he was able to taxi to the stand without further problems, as a result of which he did not attach any importance to it.

1.5. Aerodrome information

The Casarrubios aerodrome is a private aerodrome located in the province of Toledo at coordinates 40° 14' 06" N, 04° 01' 53" W and an elevation of 2,050 ft. It has a 986-m long and 26-m wide asphalt runway in an 08/26 orientation (see Figure 4). In the landing direction used in this incident (08), the available runway length was 636 m since the 08 threshold is displaced.

Figure 4. Aerial view of the Casarrubios Aerodrome (LEMT)

1.6. Aircraft inspection

The aircraft was parked in its usual hangar at this aerodrome. An initial visual inspection revealed the following damage to the aircraft:

- Fracture of the skin on the lower part of the tail with permanent deformations of the fuselage in the adjacent area and ascending at about a 45° angle with respect to the aircraft's longitudinal axis.
- Fracture of the interior structure in the same area (see Figure 2).
- Deformation of the belly access panel of the fuselage corresponding to the main landing gearbox with fracture of some of the screws that fasten this panel to the fuselage.
- Cracks in both rear windows of the aircraft.
- Missing fairing on the right main landing gear wheel and damage to the wheel fairing including scratches in the fairing area where the leg is attached to the fuselage.

Figure 5. Close-up of the right wheel bushing displaced from its housing

- Damage to the left main landing gear wheel and leg fairings consisting of scratches in the fairing area where the leg is attached to the fuselage. There were no scratches between the wheels and their fairings or in the bottom of the fairing from contact with the terrain.

The marks left by the aircraft on the runway revealed the abnormal behavior of the landing gear. It was thus decided to conduct a more in-depth inspection of this structure. The right wheel fairing was removed easily due to the absence of the wheel fairing (see Figure 5), and clearly showed that the bushing situated between the gearbox socket and the leg itself was not in its housing (see Figure 5). The other leg was then checked. Though the check was made more difficult by the fairing, it was likewise noted that the bushing was in the same condition as the right one, out of its housing.

A second inspection, arranged at the request of the manufacturer, was conducted by their experts, the CIAIAC, a CIAIAC expert on support structures, and the DGAC Certification unit as the national authority on airworthiness and continued airworthiness. The goal of this inspection was to obtain a more detailed assessment of the damage and of the possible causes.

The following checks were conducted on the aircraft:

- Check for damage to the engine gearbox and to the engine itself.
- Individual check of the bolts that fasten the wing to the fuselage to visually observe for any obvious possible deformations and structural damage.
- Removal of the interior cabin panels to check for possible deformations in the structure.
- Inspection of nose gear.

No significant anomalies were noted during any of these checks.

- Check of tire pressures, which revealed significant differences:
  The tire pressures with respect to nominal were as follows:

  — Nose wheel at 77.5% of nominal pressure.

— Main left wheel at 66% of nominal pressure.
— Main right wheel at 68.5% of nominal pressure.

- Check of the clearance in the leg housing, with and without bushings, measuring the horizontal and vertical displacement at the end of the wheel axle. There was no appreciable difference to the naked eye, though a subsequent comparison of the results against nominal values revealed the following differences:

	RH with busings	LH with busings	RH w/o busings	LH w/o busings
Vertical	0.2 cm	0.2 cm	0.5 cm	0.3 cm
Longitudinal	0.35 cm	0.3 cm	0.7 cm	0.5 cm

- Measurements of the inner diameter on the gearbox socket, outer diameter of the leg, bushing thickness and comparison with nominal values:

— The maximum play with the dimensions specified by the manufacturer was 0.016 inches.
— The play from the measurements taken during the aircraft inspection was 0.03125 inches, double that specified.

- Disassembly of the main landing gear along the same general lines as those specified for a post hard landing check as detailed in the Maintenance Manual.
- Check of the hydraulic liquid level and inspection of brakes components without significant anomalies detected.
- The leg attachements to the landing gearbox were checked. No significant anomalies were detected.

1.7. Marks on the runway

The marks left on the runway by the aircraft tires (see Appendix A) show an initial continuous segment that deviated from the runway centerline to the left. The tracks then oscillated continuously before becoming discontinuous, with a change in angle with respect to the aircraft's longitudinal axis, and non-parallel, and dashed, as if the airplane had been "hopping" alternately from one wheel to the other. There was a sandy area on the runway which the airplane was determined not to have traveled over and which shows three perfectly distinct tracks (see Figure 6).

The tire tracks stretched over a distance of some 260 m and ended about 100 m before the asphalted end of the runway.

Figure 6. Close-up of tire tracks on sand and on asphalt

1.8. Investigation

Information was requested from the manufacturer regarding different aspects involving the aircraft. The manufacturer reported that Columbia models 300-350 and 400 had a similar fuselage and structure, with differences in their equipment and, in the particular case of the 400, the installation of a turbocharged engine. It also reported that all the structures were subjected to various static tests, static overload, dynamic drop, fatigue, ground and in-flight vibration and other tests as part of the aircraft certification process.

According to the incident Aircraft's Build Records, there had been non-conformities during the manufacturing process prior to delivery. This document noted, among others, the following items:

- Retouch and repair of composite material in several areas of the fuselage due to impact from hail during a significant storm event while the aircraft was being kept outdoors at the manufacturer's facilities awaiting delivery to the owner. According to the figure showing the damage, one of these retouches was located in the tail, near the area that fractured during the incident. The manufacturer reported that the damage to the tail from the hail was aesthetic and that it had not affected the strength of this area.
- Change of the main gear bushings due to improper use of the specified adhesive.

1.8.1. *Change of adhesive in the bushings*

The manufacturer reported that the adhesive used to fix the bushings to the gearbox had been changed. Although the Maintenance Manual makes reference to the adhesive Loctite 675, the last revision to the Maintenance Manual specified the use of a new adhesive, Loctite 638, which had actually been applied to the aircraft in question according to the information noted in the Aircraft Build Records. The reason for the change, according to the manufacturer, was that the new adhesive offered greater strength and was less sensitive to the surface preparation when reinstalling the bushings, as well as to the technique used for their installation. The change from Loctite 675 to Loctite 638 took place in February 2004. Although the aircraft was delivered in 2006, the Maintenance Manual provided to the owner did not reflect the use of this new adhesive on this aircraft, though it did figure in the manufacturer's records of non-conformance. No explanatory or additional notes were provided to the owner to inform him of this difference in the aircraft with respect to the Maintenance Manual.

In August/September 2007, in the Columbia webpage forum, several owners/pilots expressed their concerns over some cases where the bushings were starting to move. Some admitted they had been warned by the maintenance mechanics during various inspections (in the annual inspection, before the 100-hour inspection), who stated it was common for the bushings to shift. One of those affected stated that while taxiing, he heard a sound behind the seat and that one of the bushings had detached. This occurred while braking sharply to make a turn.

The manufacturer reported that the bushings were not subjected to any loads in any in-flight or landing scenarios for which the aircraft was certified that could cause them to shift. The purpose of the bushings is to avoid undue long-term wear of the leg and to make the cabin more comfortable.

Notification of another change in adhesive, to Loctite 660, was made later in order to ensure a stronger bond. After the change from 675 to 638 a couple of additional cases of loose bushings were reported, though the manufacturer was not aware of the appearance of any new cases involving Loctite 660.

1.8.2. *Analysis of tire pressure*

As a consequence of the low tire pressures recorded during the aircraft inspection, the tires were inflated to the nominal pressure specified in the Maintenance Manual. Weeks later (to simulate the period elapsed between the date of the 50-hour inspection and the date of the incident) the pressure was re-checked. No significant losses were noted.

1.8.3. *Analysis of the clearance noted in the train resulting from the missing bushings*

The manufacturer was consulted several times regarding the influence on the landing gear's behavior of the clearances caused by missing bushings with respect to the nominal values.

According to the manufacturer, the play between the leg and the gearbox socket caused by missing bushings does not adversely affect the tolerances specified in the Maintenance Manual (see Section 1.3.3):

- A vertical displacement would cause a change in the camber alignment. According to the manufacturer, considering that the leg can pivot on its upper attachement point, this would correspond to an angular deflection of 0.14°. The aircraft records show that the original camber as measured at the time of manufacture was 2.2° on the left wheel and 2.1° on the right. An increase of 0.14° would result in cambers within design tolerance (1.3°-3.3°), meaning that even without the bushing, the camber would, according to the manufacturer, be within design limits.
- A displacement of the wheel forward or aft could result in changes to the toe-in/toe-out value. The largest displacement, 0.7, was noted in the right wheel. The value with the bushing installed was 0.35. This would give rise to a maximum displacement of 0.35 cm. According to the manufacturer, considering that the leg can pivot on its upper attachement point, this would correspond to an angular deflection of 0.17°. The aircraft records show that the original toe-in/toe-out recorded at the time of manufacture was 0.44° on both wheels. An increase of 0.17° would result in values within the design range (0.25°-0.75°), according to the manufacturer.

1.8.4. *Analysis of play between gearbox socket and leg with bushing installed*

The maximum play allowed, according to the manufacturer, between the gearbox socket and the leg with the bushing installed is 0.016 inches. The actual value on the incident aircraft was 0.03125 inched, about double.

The data on the Technical Data Sheets for the different types of adhesives used (Loctite 638 and 660) show that the separations between bonding elements can be 0.01 inches with Loctite 638 and 0.02 inches with Loctite 660 (the nominal separation was 0.016 inches). The allowed temperature range for the Loctite 660 increased up to a value of –50°.

The manufacturer reported that the difference between the actual and required separations for the use and performance of the adhesive was negligible since the bushing is designed as an oversized, segmented ring that provides a spring action, thus resulting in a very low tolerance.

The manufacturer was also asked about how the hot-cold cycles experienced while moving the aircraft from Oregon to Spain could have affected the behavior of the adhesive. The manufacturer did not consider this factor important given that the clearance tolerances were within design limits (see Section 1.8.3).

The Technical Data Sheets show that the 660 adhesive was not stronger than the 638, as claimed by the manufacturer (the ISO 10123 compression shear strength after a 24-hr cure is 23 N/mm^2 for Loctite 660 versus 25 N/mm^2 for Loctite 638). The criteria used by the manufacturer to select this new adhesive was that more viscosity prevents the adhesive to drip out of the gear socket.

It is not known what criterion was used by the manufacturer to select the adhesive and why it was decided to change the chosen adhesive once more.

1.8.5. *Actions taken by the manufacturer*

At the CIAIAC's request, the manufacturer reported that other cases existed of bushings coming loose due to improper preparation and installation. The Product Integrity Board had been investigating these occurrences and had established the following changes to improve the bushing retention rate in the housing:

- Technicians had been advised to properly prepare the surface prior to installing the bushings.
- The adhesive type was changed from Loctite 638 to 660 to ensure a stronger bond.
- An Obligatory Service Bulletin (SB-07-005A) had been issued which required that the bushings be inspected during the annual inspection or in the next 100 hours. If the bushings were found displaced during this inspection, new ones had to be installed using Loctite 660. It was subsequently noted that in the latest version of the Service Bulletin (SB-007-005C, 7 April 2008), the P/N of the bushings was also changed. According to the manufacturer there is no change to fit, form or function between the old and new bushings. A new item was also added to the Pre-flight Checklist that required pilots to ensure that the bushings were correctly housed as part of every pre-flight check.
- Lastly, the Product Integrity Board was also examining several engineering options to improve the design.

In January 2008, new cases of bushings shifting in their housings appeared in the forum. In one of these cases the pilot started to notice strong vibrations while braking during the landing roll.

Although the manufacturer was asked about these cases and the circumstances and consequences in each, no reply has been received. There is only the information extracted from the forum.

After the comments phase, manufacturer informed that the main gear leg design has been updated with a new machined shoulder or "bump ring" that fit against the gear box socket and physically retained the gear bushing in the socket should Loctite failure occur. This design improvement was implemented in early 2008 only for production aircraft and was available to fielded aircraft as a replacement part. CIAIAC considered that this action did not assure that other cases with loose of bushings in existing aircrafts and their consequences could occurred, so CIAIAC keeps the Recommendation issued at the end of this report.

2. ANALYSIS AND CONCLUSIONS

2.1. Analysis

2.1.1. *Hypotheses considered during the investigation*

Over the course of the investigation several hypotheses were considered that could have contributed to the incident:

Hard landing

Initially it was thought a hard landing could have damaged the tail. Although the post hard landing inspection conducted by the manufacturer did not rigorously adhere to the procedure specified in the Maintenance Manual, it was adequate enough to be able to rule out this hypothesis.

Damaged tail area

According to the aircraft's manufacturing records in the Aircraft Build Records, it was discovered that the aircraft had required repair of damage suffered during a significant hail storm prior to delivery to the owner. The manufacturer reported that the damage was just aesthetic and did not affect the structural strength of the aircraft. No determination could be made regarding whether the fracture area in the tail passed through a point repaired at the factory prior to delivery.

Tire pressure

The manufacturer emphasized that the pressure values present in the tires were very low. In his opinion, this low pressure could have resulted in the following:

- The tires would flatten such that they would be wider at the bottom, which would reduce the clearance to the wheel fairing, potentially resulting in the tires "grabbing" the fairings under lateral loading.

- The tires would have a greater contact area with the ground leading to increased friction with the runway.

During the inspection it was noted that the wheel fairings did not exhibit any signs of contact with the wheels and that the wear on the tires was not consistent with a greater contact patch with the ground. The wear on the tires was more or less homogeneous except for some areas that showed signs of sliding.

Moreover, neither the visual inspection conducted on the first day by CIAIAC investigators nor a month later by representatives of the manufacturer revealed an alarmingly low tire pressure. It was not until the exact value was determined using a pressure gauge that this factor was considered.

Subsequently the CIAIAC conducted tests on the tires by inflating them to nominal pressure and measuring them weeks later (to simulate the period between the 50-hr inspection and the date of the incident). No significant loss of pressure was noted. It seems reasonable then that the low tire pressure was already present in flights previous to the incident without causing any vibrations during the landings.

Pilot actions

The application of substantial differential braking during the landing roll had induced, according to the manufacturer, an oscillation in the braking and the subsequent locking of the main gear wheels, which caused the aircraft to start vibrating violently.

The tire marks showed no obvious signs that both tires had locked and were slipping down the runway because the wear was even. The marks did show that the airplane had been "hopping" first on one wheel and then on the other as the angle with respect to the airplane's longitudinal axis varied. There was a sandy area on the runway which revealed that the airplane's wheels were not rolling and where three perfectly distinct marks could be seen (see Figure 6). The only area of uniform wheel rotation was during the initial segment, in which the aircraft started to veer from the runway centerline, leaving uninterrupted skid marks before subsequently starting its continuous oscillations (see Appendix A).

Shifting of the bushings in their housing

The manufacturer reported that the play between the leg and the gearbox socket resulting from the missing bushings had no adverse effects on the tolerances specified in the Maintenance Manual (camber and toe-in/toe-out). See Section 1.8.3.

The design tolerance specifies the limits for a certain parameter but does not consider the presence of a range of values, that is, of play, which is what the lack of the bushing caused in this case.

The maximum play allowed between the gearbox socket and the leg with the bushing installed is 0.016 inches. That measured on the incident aircraft was 0.03125, approximately double.

Although the manufacturer reported that this piece of data was negligible since the bushings were segmented and oversized (allowing for their adjustment with very little tolerance), the requirements for using the adhesives specified that the separation between the bonded elements be 0.01 inches with Loctite 638 and 0.02 inches with Loctite 660 (the nominal separation was 0.016 inches). The Technical Data Sheers also showed that the 660 adhesive was not stronger than the 638, though this was the reason for changing to Loctite 660 (see Section 1.8.4). The Loctite 660 did, however, allow for the separation between the inner diameter of the gearbox socket and the outer diameter of the bushing to conform to the nominal separation specified by the manufacturer (0.016 inches).

The manufacturer informed that that the main gear leg design has been updated with a new machined shoulder or "bump ring" that fit against the gear box socket and physically retained the gear bushing in the socket should Loctite failure occur. CIAIAC considered that this action did not assure that other cases with loose of bushings in existing aircrafts and their consequences could occurred, so the Recommendation keeps on issued at the end of this report.

2.2. Conclusions

Once the information gathered on the incident is presented and analyzed, the following conclusions can be drawn:

- The aircraft had 54.6 flying hours, of which 34.5 had been utilized in transporting it from the factory in Bend (Oregon) to Casarrubios (Madrid) for delivery to its owner.
- At the 44.2 flying-hour mark, the 50-hr inspection was performed on the aircraft as per the Maintenance Manual.
- The aircraft encountered severe vibrations during the landing roll and deviated from the runway centerline to the asphalt edge without exiting before coming to a stop at the end of the runway. The right and left gear alternately contacted the ground at angles that varied with the aircraft's longitudinal axis.
- The tail of the aircraft fractured at the juncture of the vertical shear web and the antenna bulkhead.
- The composite material that makes up the aircraft's fuselage, particularly in the proximity of the tail fracture, had been repaired after being damaged by hail.
- Various inspections revealed that the average tire pressure was low and that the bushings between the gear legs and the gearbox sockets were out of their housing.
- Subsequent tests made by the CIAIAC verified that the tires did not exhibit a significant loss of pressure.

- The low tire pressure, therefore, could have been present during the 50-hour inspection, which was the only time since delivery that the pressure was adjusted (as noted on the inspection work order).
- The pilot performed at least five landings after this inspection without noting any anomalies.
- The purpose of the bushings is to avoid undue long-term wear of the leg and to make the cabin more comfortable
- The clearances measured during the inspection and resulting from the absence of these bushings were within the design tolerances specified by the manufacturer.
- On the Columbia forum used by pilots to note their experiences with their aircraft, there were several reports that made reference to bushings that were starting to shift. One of the cases linked the loss of the bushings with episodes of loss of directional control and vibrations during landings.
- It is not known whether, in these cases reported in the forums, the tire pressure had been checked or whether the pilots had applied differential braking, thus causing the vibration.
- The manufacturer reported that the adhesive used to fix the bushings to the gearbox had been replaced (Loctite 675) and that the one referenced in the Maintenance Manual had not been used on the aircraft since the new adhesive (Loctite 638) had been applied at the factory.
- There is no record of this change in the documentation provided to the owner. The Maintenance Manual still made reference to the old adhesive.
- The manufacturer admitted to being aware of an occasional loss of a bushing and that the adhesive had been changed to address this (from Loctite 675 to Loctite 638). The adhesive was subsequently changed again (from Loctite 638 to Loctite 660).
- The information on the Technical Data Sheets for the 638 and 660 adhesives show that the separation between the bonded elements can be 0.01 inches for Loctite 638 and 0.02 inches for Loctite 660. The nominal separation between bonded elements was 0.016 inches, meaning this particular bushing installation would not comply with the separation requirements specified for Loctite 638, which was the adhesive used in the incident aircraft.
- All of the actions taken by the manufacturer (inspections, application of new adhesives, adequate preparation of the surfaces, pre-flight inspection, design assessment, etc.) have been geared toward ensuring the bushings remain in their housing. In fact the main gear leg design has been updated so as to retained the gear bushing in the socket should Loctite failure occur.
- It has not been possible to determine whether the strength of the tail area that fractured was within design limits or whether it was affected by another factor (manufacture, hail storm, repairs, etc.).

2.3. Causes

Based on the information available, the incident is considered to have been caused by a large vibration experienced by the aircraft as the brakes were applied over a long

stretch of the landing roll and resulting from the bushings in the landing gear legs being dislodged from their housing.

The use of differential braking by the pilot when faced with the deteriorating control of the aircraft could have aggravated the duration and amplitude of the vibration. The low tire pressure could also have contributed to a decreased braking efficiency and a prolonged landing roll.

3. SAFETY RECOMMENDATIONS

This incident resulted mainly from the anomalous behavior of the gear, probably aggravated by other factors such as the tire pressure and the pilot's actions. The presence of this phenomenon in several other cases, though to varying degrees of intensity, along with the actions taken by the manufacturer aimed exclusively at ensuring that the bushings remain in place and function properly, require the issuance of the following recommendation:

REC 02/10. It is recommended that FAA requires manufacturer CESSNA (formerly COLUMBIA) to undertake the necessary measures to ensure the continuous airworthiness of the aircraft already manufactured that do not have incorporated the landing gear design modifications taken by the manufacturer after the incident.

APPENDIX A
N1271B marks on the runway

Figure 7. General view of traces on Casarrubios Aerodrome runway