DATA SUMMARY

LOCATION

Date and time	**Thursday, 6 April 2006; 09:37 UTC (11:37 local time)**
Site	**Girona Airport (LEGE)**

AIRCRAFT

Registration	**EC-IPO**
Type and model	**CESSNA 421-B**
Operator	**Private**

Engines

Type and model	**TELEDYNE CONTINENTAL GTSIO-520-H**
Number	**2**

CREW

	Pilot in command	Student pilot
Age	**33 years old**	**38 years old**
Licence	**CPL(A). ME CRI**	**CPL(A)**
Total flight hours	**2,700 h**	**2,075 h**
Flight hours on the type	**56 h**	**140 h**

INJURIES

	Fatal	Serious	Minor/None
Crew			**2**
Passengers			
Third persons			

DAMAGE

Aircraft	**Minor**
Third parties	**Minor damage to the runway**

FLIGHT DATA

Operation	**General aviation – Flight training – Dual**
Phase of flight	**Landing run**

REPORT

Date of approval	**28 May 2008**

1. FACTUAL INFORMATION

1.1. Description of the event

On the day of the incident, 6 April 2006, the aircraft, a CESSNA 421-B, registration EC-IPO, had scheduled a local instruction flight with several takeoffs and landings into the course for the multi-engine instructor rating (ME CRI) of a student who already had his commercial pilot license. The aircraft took off from Girona airport at 08:25 UTC (10:25 local time) with two occupants aboard, the instructor and the student. The incident took place during the first landing run, which proceeded normally at first but which gradually saw the aircraft deviate to the left before departing the runway to come to a stop after a few meters on the grass (Fig. 1), resting on the outer part of the left wing and the other two wheels.

There were no fires or fuel leaks.

Figure 1. Aircraft following the incident

1.2. Injuries to persons

Neither occupant was injured. Both exited the aircraft under their own power.

1.3. Damage to aircraft

During a visual inspection of the aircraft performed at the incident site, it was noted that the left main landing gear leg was almost completely retracted inside the wheel

well, and that some pieces had broken off its actuating mechanism. Consequently, the aircraft had fallen toward that side, resulting in scratches along the bottom of the fuselage and left wing, especially the left flap, as well as in a bent left wingtip.

It was also noted that the tips of the left propeller blades were bent and worn by abrasion, indicative of having struck the runway several times. The trailing edge of the left-side flap and some components from the left wingtip were also scraped.

1.4. Personnel information

The crew consisted of an instructor as pilot in command and a student pilot who was the pilot flying throughout the operation.

The information available on this pilot is as follows:

Age:	38	
Nationality:	Spanish	
License:	Commercial Pilot - Aeroplane	
Experience:	Total:	2,074:52 h
	On the type:	140:23 h
	In the last 30 days:	26:25 h
	In the last 24 hours:	1:55 h

The information available on the instructor is as follows:

Age:	33	
Nationality:	Spanish	
License:	Commercial Pilot - Aeroplane	
Ratings:	Multi-engine and multi-engine rate instructor (ME CRI)	
Experience:	Total:	2,700 h
	On the type:	56 h

1.5. Aircraft information

1.5.1. *General*

Registration:	EC-IPO
Manufacturer:	Cessna Aircraft Company

Model:	421-B
Serial number:	421-B0509
Year of manufacture:	1974
MTOW:	3,380 kg (7,450 lb)

1.5.2. *Airworthiness certificate*

Class:	Normal
Issue date:	14 Dec 2004
Renewal date:	22 Dec 2005
Valid until:	20 Nov 2006

1.5.3. *Maintenance record*

Total hours:	7,033 h, 40 minutes
Flying hours in previous five months:	129 (from 21 Nov 2005 to 06 Apr 2006)

Aircraft records show that all the inspections prescribed by the approved Maintenance Program had been performed. According to said documentation, the last inspections made had been:

- Annual/200-hour inspection, on 08 Nov 2004 with 6,933:37 h on the aircraft
- 50-hour inspection, on 29 Jun 2005 with 6,978 h on the aircraft, and
- Annual/200-hour inspection, on 15 Dec 2005 with 6,994:30 h on the aircraft.

The manufacturer, Cessna, had issued SID nos. 32-10-03 and 32-30-05 on 3 Mar 2003 as part of its Supplemental Inspection Document (SID), affecting the landing gear for this type of aircraft and applicable to the serial number of the incident aircraft.

- Bulletin SID no. 32-10-03 specifically requires an inspection of the pivot bolt for each main gear, to be made on the disassembled bolt to ensure its integrity against any evidence of shearing. The document states that the bolt is to be replaced if any evidence is found and that the initial verification must be made after 1000 landings or 3 years, and be repeated every 500 landings or 3 years thereafter.
- Bulletin SID no. 32-30-05, titled "Main/Nose Gear Retraction Systems Tear Down and Inspection" indicates as its purpose that of "inspecting for fatigue cracks and excessive wear in mechanisms, bushings, bearings, attachment holes in structure and attaching hardware which could hinder proper rigging and cause gear down position

failures or structural failures." The bulletin requires the tear down and inspection of all the landing gear components and assemblies for cracks, corrosion, orifice ovalization and excessive wear, and to replace components as required (detectable crack size: 0.25 inches). The document calls for an initial check after 7,500 landings or 15 years, to be repeated every 5,000 landings or 10 years.

The aircraft documentation states that these two bulletins, SID 32-10-03 and SID 32-30-05, were implemented during the aforementioned annual/200-hour inspection done on 08 Nov 2004, during which the relevant required inspections were made.

These checks, therefore, were made with a total of 6,933:37 flying hours on the aircraft. From then until the time of the accident, the aircraft logged an additional 100:03 h and 90 landings. This information shows that the aircraft was within the time margin before the next inspection required in both bulletins.

1.5.4. *Description of landing gear system*

The Cessna 401, 402, 411, 421 and 425 aircraft share the type certificate and also the same landing gear mechanism and model. The Cessna 310, 320, 335 and 340 models likewise share the same landing gear.

Figure 2 shows a diagram of the left landing gear leg in its extended position. Also shown in the figure is a detailed view of the leg's mechanism with the names of those components most relevant to this incident and, in red, the breaks discovered, to be addressed later.

The gear is actuated via an electric motor and reduction gear, located in the central fuselage under the deck (not shown in the figure). The rotation of this motor is transmitted to the three legs, left, right and nose, through a set of levers and a torque tube which moves the push-pull tube to directly activate each leg's mechanism.

Looking at the left leg only (Fig. 2), the operation of the system to retract the gear would be as follows: the electric motor would be powered to turn such that the push-pull tube would move toward the leg, pushing the bellcrank, to which it is attached. The push and motion of the push-pull tube make the bellcrank rotate and push on the pivot bolt, which is located in the truss assembly.
This push generates torque in the pivot bolt and acts to retract the gear assembly (leg rotates toward the fuselage). Simultaneously, the rotation of the bellcrank causes its lower arm, the longer of the two, to move the hinged bar located at the end of the arm. This motion has two effects: it overcomes spring pressure to separate the limit switch from the leg, which extinguishes the "gear locked" light; and, it makes the other end of the bar pull on the overcenter of the lower side link, to which it is attached. This connection is also hinged and goes through the adjusting screw, whose function is

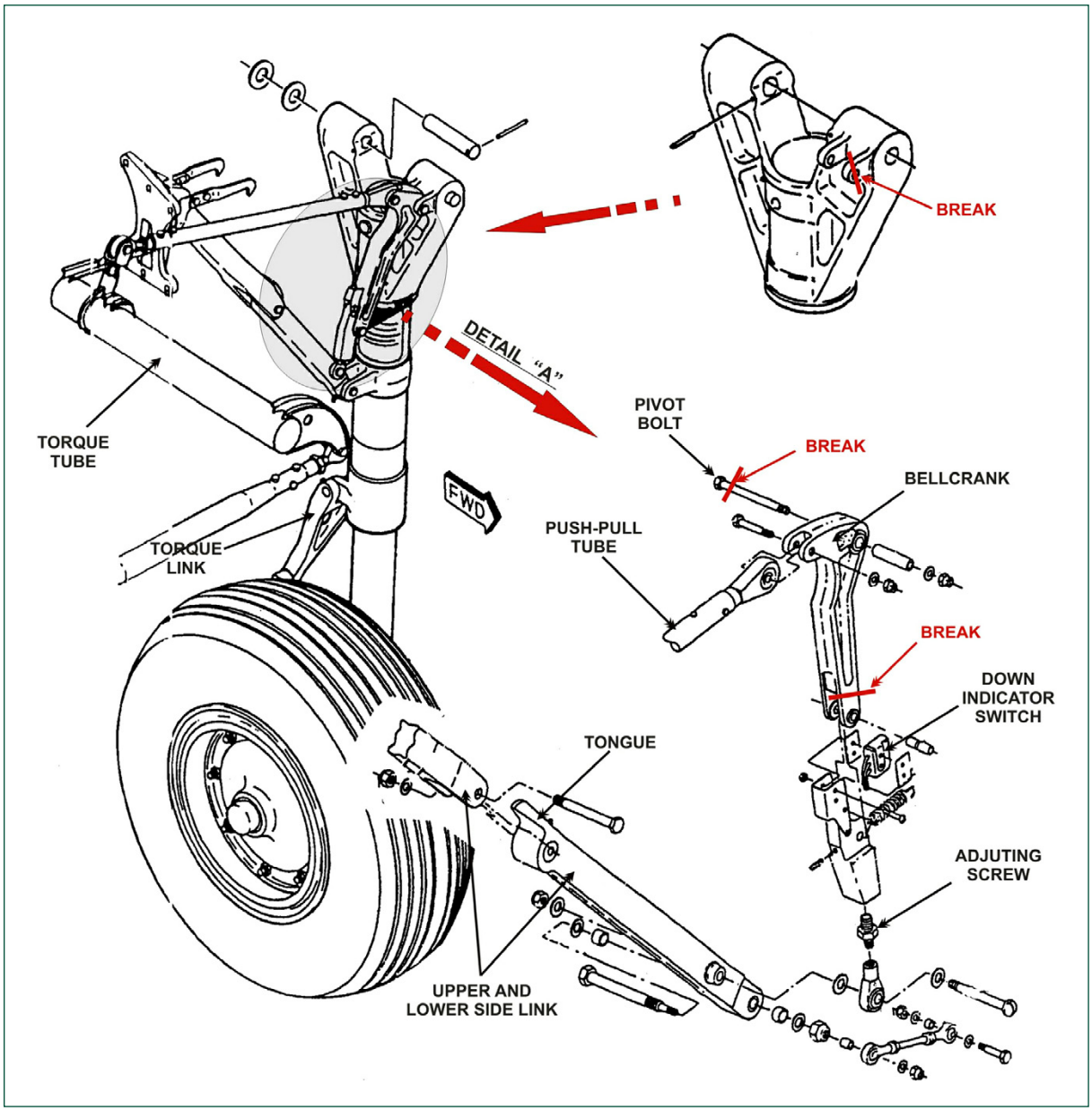

Figure 2. Diagram of the left gear leg

explained later, which is attached to the end fitting and the side brace lock link. As shown in Figure 2, pulling on this link causes the lower side link to fold upward, allowing the leg to rotate toward the fuselage.

The side link assembly consists of two arms, upper and lower, hinged at the center, which serves not only to position the leg in its down position, but also to absorb any lateral loads that may be imparted on the gear during takeoffs and landings. The geometric arrangement is such that when the gear is lowered, the side link extends and is locked in place by the bellcrank, which forces its hinge to extend past the imaginary line that would join the ends of its arms. This lock, known as the overcenter, is

completed by means of a tab at the hinged end of the lower side link of the assembly, shown in Figure 2, which limits the maximum possible value of the overcenter (the side link assembly is sometimes called the overcenter) and doubles as a mechanical stop which keeps the assembly from bending downward.

The position of the overcenter is regulated by adjusting the length of the hinged lower bellcrank arm, which is joined to the side link assembly via the adjusting screw, which is threaded at both ends. If the assembly is properly adjusted, when the sidelink assembly reaches the overcenter, the lower hinged bellcrank arm is straight and in its maximum length position (Fig. 2).

With the gear in a down and locked position, the geometric configuration of the leg distributes the vertical and lateral loads along the leg's own column or along the side link assembly, respectively. The actuating mechanism is not designed to withstand large loads, its function being to maintain the overcenter position.

1.6. Meteorological information

Local information gathered onsite the day of the incident indicated the presence of scattered clouds not affecting visibility and the absence of wind gusts and any other weather phenomena which may have played a role in the incident.

The weather data at the time of the incident was 15 °C, 72% humidity, light breeze at 3 kt from the east-northeast and visibility of 10 km.

1.7. Aerodrome information

At the time of the incident, the aircraft was landing on runway 02, which was the runway in use.

Runway 02-20 at Girona airport is paved and measures 2,400 m long by 40 m wide. Runway 20 features an ILS for approach, while runway 02 has a visual approach system with a PAPI (Precision Approach Path Indicator), which uses lights to indicate the glide path. There are also runway centerline lights about every 50 m, the first one being in the runway 02 threshold.

1.8. Wreckage and impact information

An onsite investigation done on the runway following the incident revealed significant marks left by the aircraft, resulting in minor damage. Marks from the left propeller blades were identified starting 650 m from the runway 02 threshold, and continuing

for some 300 m along a line that gradually deviated to the left with respect to the runway centerline. A total of 162 marks some 30 cm long were counted perpendicular to the runway, their separation increasing from 0.6 m to 2.10 m. Other scratch marks were found on the runway surface, undoubtedly left by the left wheel and torque scissor components as they scraped along the runway. Also noticeable were tread marks, both for the left gear, which discontinued after some distance, and the right, with hard braking indicated by a 7.9 m segment of higher intensity.

The aircraft ended up departing the runway to the left and onto a grassy area, with the nose wheel 32.7 m away from centerline light no. 18 and 7.4 m away from the edge of the runway.

1.9. Tests and research

1.9.1. *Eyewitness statements*

Both pilots onboard, the instructor and the student, who was the pilot flying during the flight, agreed in their statements and indicated that they checked during the pre-landing that the gear indicating lights were green (gear down and locked) and that there was no audio warning upon throttling down. They likewise agreed that the landing took place in low-wind conditions and proceeded normally until, once on the ground, they felt the aircraft veer left. Both applied right pedal to correct the heading and, feeling increased demand, moved the stick to the right when the wing started to settle. The aircraft continued its turn to the left until it came to a stop off the runway.

In a subsequent conversation, the pilots stated that they remembered hearing the landing gear audible warning just as they started sensing the need for more pedal to keep the aircraft aligned with the runway.

Also available were statements from the ATC controller during the incident and from an airport scheduling and operations specialist. Both virtually agreed that the landing run proceeded normally until the aircraft started to veer to the left (with the former specifying a point at the runway C1-1 exit, which is between lights 13 and 14, at about 650 m, and the latter 200/300 m away from the landing point). Only the scheduling and operations specialist included in his statement that, in his opinion, the landing had seemed harder than usual.

1.9.2. *Detailed inspection of the left landing gear*

Following the incident, the following were noted during a hangar inspection of the left gear:

- The right lug fitting as seen from the wing root (that is, the one in the front) which supports the pivot bolt in the truss assembly was broken at the hole for the pivot bolt. The detached piece from the lug was later found. The break is shown in Figure 2, and Figure 3 shows the lug piece superimposed on the bellcrank. This superposition revealed that the pivot bolt hole was slightly ovalized.
- The pivot bolt (NAS 464P4-26) also broke between the left lug of the aforementioned fitting, which was intact, and the bellcrank, as shown in Figure 2.
- The lower right lug on the bellcrank was fractured in the section where the thickness begins to increase and which corresponds with the limit switch for the leg. As shown in Figure 4, this break involved a bending component toward the outside of the bellcrank (front of the aircraft) and also affected the lug bushing.

Figure 3. Break of the bellcrank lug

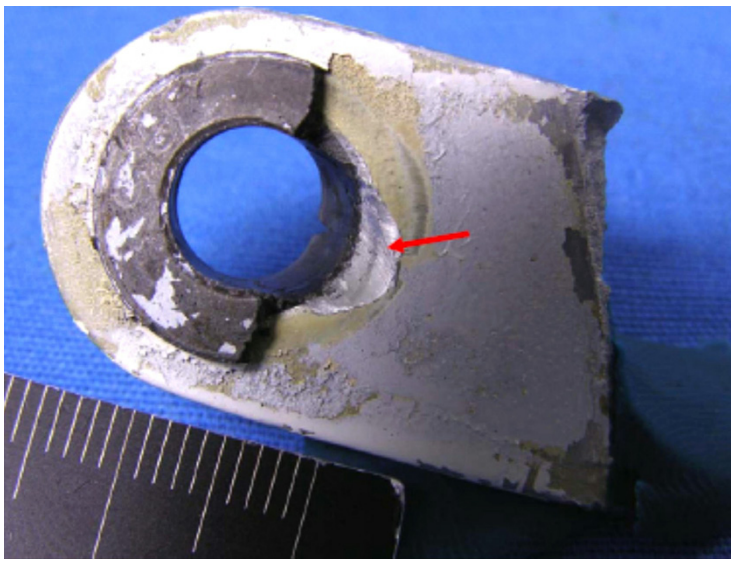

Figure 4. Break of the lower bellcrank lug

- Slight play was noted in the LH torque link. This was the result, and not the cause, of the incident. The lower front part of the torque link was also fretted from making contact with the ground. Friction marks from the ground were also noted on the outer wheel rim.
- There were no signs of lateral slippage on the left gear tire. Such signs were noted on the right.
- Lastly, there were no deformations or stress marks on the hinge tab between the two parts of the side link assembly (Fig. 5).

No fractures or defects were noted in the right gear.

Figure 5. Condition of the lower side link following the accident

1.9.3. *Analysis of the breaks in the pivot bolt and lugs*

The components that fractured in the incident, the pivot bolt, the lug in the truss assembly, the lower lug in the bellcrank and its bushing were all sent to a specialized laboratory for an analysis of the cause of the fractures.

The analyses indicated that all the fractures, save for the lug bushing, had resulted from exceeding the mechanical limits of the materials involved. An existing plastic deformation was found in the break of the lower bellcrank lug, while the bushing had suffered a brittle fracture.

There were no defects of a metallurgical nature which could have aided the fracture process in any of the components. It is logical to conclude that the breaks were caused by overstrain.

Specifically, for the pivot bolt (NAS 464P4-26), an analysis was performed to compare the pivot bolt sheared in the incident and the undamaged pivot bolt from the right gear. This analysis showed that though both bolts were of the same type, their chemical compositions were slightly different, resulting in different breaking loads, the one for the sheared bolt being greater (129.78 kg/mm^2, versus 123 kg/mm^2). Both were near or above the specification required for the bolt type (112/126 Kg/mm^2). It should be noted that these results were obtained through a hardness test, and are thus for information purposes only.

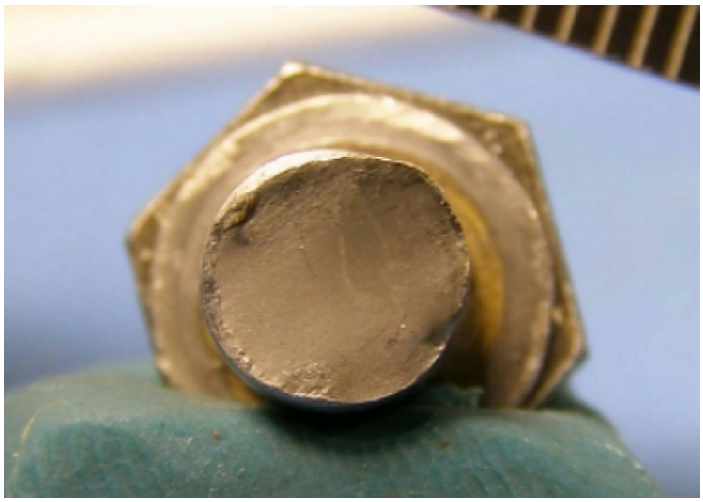

Figure 6. Fracture of pivot bolt NAS 464P4-26

A fractographic analysis of the fracture surface on the pivot revealed a smooth appearance (Figure 6) and a certain degree of plastic deformation. The break is of a ductile nature, there being no signs of a pre-existing flaw or crack.

1.10. Additional research

During the investigation, the maintenance process involving the check of the landing gear was observed for a Cessna A-310 aircraft, similar to the model in the incident and with which it even shares components. Particular attention was paid to wear and clearance conditions, and to the procedure used to adjust the overcenter. The following conclusions were drawn:

- Some clearance and slight wear were noted in the actuating mechanism components for the main gear legs, especially in a plane perpendicular to the mechanism. It is considered unlikely that these could have led to the unlocking of the overcenter linkage.
- The procedure used to adjust the overcenter linkage seems simple and easy to follow. First the lower side link is released until it is resting on the tab. The length of the hinged link is then adjusted to that of the lower link. The adjustment is considered complete when the mechanism returns to the locked position solely under its own weight, even without the wheel, after being taken out of said position by pushing toward the fuselage on the hinge of the lower bellcrank arm and on the link on which the adjusting screw is located.
- The unlocking procedure mentioned previously allows the leg to turn and move 6 inches toward the fuselage without any motion of the push-pull tube.
- The lower hinged arm of the bellcrank on which the adjustments are made can be subjected to a compressive pre-load if the arm is lengthened excessively. If its length is unduly reduced, too much slack may be introduced in the lower side link assembly, thus allowing it to move in an oscillatory fashion.

1.11. Similar occurrences

In the CIAIAC database, there are two previous accidents (see reports A-71/2002 and A-41/2004) and one subsequent incident IN-36/2006) to this one, involving breaks in the main landing gear extending-retracting mechanism on Cessna aircraft sharing the same landing gear design as the EC-IPO.

A-71/2002 Cessna 402-B, dated 25 September 2002, right main gear: shear fracture of a section of the bellcrank pivot bolt; fracture of one of the lugs on the front trunnion bolt supporting the pivot bolt; fracture of the bellcrank lower arm adjusting screw; and, fracture of the push-pull tube where it joins the bellcrank.

No material defects were found. It was determined that the breaks were caused by an improperly adjusted extending-retracting and locking mechanism for the RH main landing gear leg.

A-41/2004 Cessna 402-B, dated 10 July 2004, left main gear: shear fracture of a section of the bellcrank pivot bolt; fracture of one of the lugs on the front trunnion bolt supporting the pivot bolt; lateral bending failure of the lower bellcrank arm and bending of the adjusting screw. A deficiency was found in the pivot bolt material, which had a strength below specification.

IN-36/2006 Cessna 402-B, dated 03 July 2006, right main gear: shear fracture in two parts of the bellcrank pivot bolt; lateral bending failure of the lower bellcrank arm. No material deficiencies were found.

Several cases were also found in the NTSB database matching the events described in this incident:

MKC82FA174 Cessna 421A, dated 24 September 1982: the bellcrank pivot bolt sheared, as did the clevis at the lower end of the bellcrank. Both fractures were associated with overload conditions induced when the gear collapsed. There was no evidence of previous damage.

CHI89LA080 Cessna 411, dated 25 April 1989, LH main gear: the bellcrank pivot bolt broke while taxiing and turning right. The likely cause was the failure of the pivot bolt in the LH main gear assembly.

LAX92LA138 Cessna 340A, dated 11 March 1992, LH main gear: the bellcrank pivot bolt and the adjustment screw were found fractured, which led to the break of the rod end fitting. The pivot bolt exhibited clear beach markings on the fracture face. The probable cause was listed as the fatigue failure of the bellcrank pivot bolt.

CHI00LA038 Cessna 310Q, dated 26 November 1999, LH main gear: no green light indication; the bellcrank was broken and the pivot bolt bent. The landing gear locking mechanism was not properly locked.

CHI02LA210 Cessna 402B, dated 23 July 2002, LH main gear: the pivot bolt and lower side brace bolts of the bellcrank were both sheared.

LAX04LA149 Cessna 402A, dated 03 March 2004, RH main gear: shear fracture in two places of the bellcrank pivot bolt; break of the clevis ears at both ends of the bellcrank. No material defects were found. The probable cause was an improper flare by the pilot which imparted high side loadings on the RH main gear, leading to the overload failure of the bellcrank and the collapse of the landing gear.

DFW06CA175 Cessna 340A, dated 05 July 2006, RH main gear: the bellcrank pivot bolt was found broken. No probable cause was established.

One case was found in the AAIB database whose description and failure mode analysis are similar to those described herein:

EW/G2003/03/26 Cessna 310R, dated 13 March 2003, LH main gear: While taxiing at an estimated speed of 10 kt, the left gear collapsed during a right turn to exit the runway. The adjusting screw broke and the pivot bolt securing the downlock link to the side brace bolts of the bellcrank were bent.

The report notes the complicated nature of the procedure for rigging the main gear, stating how it needs to be completed from start to finish. Making small adjustments to parts of the rigging can result in the gear collapsing, according to the manufacturer.

2. ANALYSIS

2.1. Incident progression

The facts compiled above, particularly on the condition of the damaged aircraft components, eyewitness accounts, especially those of the pilots, the tracks left on the runway and the aircraft trajectory show that the landing and the initial part of the landing run proceeded normally, with the gear down and locked, and that the incident commenced with the deviation of the aircraft to the left. The eyewitness statement concerning the harder than usual landing is considered a personal opinion, given that there are no signs on the runway or damage on the gear, including the tires, other than the fractures already described to confirm the hard landing.

The post-incident inspection indicates that the left leg collapsed and slowly started a continuous, uncommanded retraction. The multiple propeller marks on the runway, first of blade strikes and then of persistent metallic contact, indicate that the process was not instantaneous, but rather gradual and ended, as inferred by the runway strikes mentioned above and the inspection of the aircraft, with the leg essentially retracted.

2.2. Analysis of the uncommanded retraction process

The geometric layout of the main gear is such that when the gear is in the proper "down and locked position," any vertical and lateral loads acting on it are supported by the leg's own column and by the lower side brace assembly, respectively. As a consequence, there is essentially no load transmitted through the actuating mechanism, thus its components are relieved of practically all loading forces.

All the fractures found in the incident, however, took place on components of said mechanism. Moreover, the laboratory analysis concluded that all fractures resulted from loads that exceeded the mechanical properties of the materials involved.

An abnormal condition must have therefore existed in the extending and locking mechanism of the LH gear which resulted in the presence of such loads on the mechanism's components.

2.3. Failure sequence

The sheared bellcrank pivot bolt, both in this case and in the others considered by this Commission, appears to be the initial component in the sequence of failures leading to the collapse of the main gear leg. This axis about which the bellcrank swivels is the only common element that failed in all four cases.

The direction of the force causing the failure of the bellcrank pivot bolt, known due to the static position of the axis following its failure in some of the cases, matches that of the reinforcing stiffener for the bellcrank, and is at about the halfway point of the angle formed by its two arms. In each of the cases, however, the force was applied from opposing sides.

The other failures in the mechanism components, the trunnion clevis ear and the bellcrank lower arm, seemed to be caused by forces and torques perpendicular to the plane in which the bellcrank itself moves during extension-retraction, as indicated by the large lateral bending component.

All the evidence from the failed components and their failure modes indicate the following sequence for the failures and the collapse of the main gear:

1. The damage starts with a single shear of the bellcrank pivot bolt (in every case the failure takes place between the rear trunnion clevis ear and the bellcrank).
2. The mechanism maintains its shape and allows the leg to lock, since the pivot bolt is still performing its function, though load is placed on one sole trunnion clevis ear.
3. Lateral forces appear on the bellcrank as a consequence of the loading asymmetry from the bellcrank pivot bolt on the front clevis ear.
4. The adjusting screw or the lower bellcrank arm clevis ears bend considerably.
5. Last in the sequence, though it may occur simultaneously with point 4, is the failure of either the front trunnion clevis ear or of the lower bellcrank arm, at which point (4 or 5) continuity is lost in the leg locking mechanism.
6. The main landing gear leg collapses slowly, even if there is not a high load on that leg at the same time.
7. During the collapse, mechanical interference may occur between linkages or components in the leg, leading to the secondary failures mentioned in point 5 and/or new damage to the mechanism's components.

Other signs, such as the absence of damage to the rear clevis ear of the trunnion (which ceases to function once the pivot bolt fails), the gradual collapse of the train once it

unlocks, the absence of forces perpendicular to the plane in which the mechanism moves when operating properly and the lack of marks on the tab at the overcenter position on the lower side link support the failure sequence described.

2.4. Origin of the overload on the mechanism

As already mentioned, the failure of the extension-retraction mechanism was caused by the presence of loads in excess of design criteria. Such loads, therefore, should not appear unless the mechanism is improperly adjusted such that these loads are introduced during the gear locking process and/or are distributed during the landing in a way inconsistent with a properly functioning mechanism, when these loads are absorbed by the trunnion (vertical) or the lower side link or overcenter (lateral).

The movement of the assembly that lowers the landing gear, including the actuating electrical motor, and its cockpit indication, can be adjusted or calibrated in three ways. It also features the generic mechanical adjustments present in any mechanical joint.

a) The first involves the positioning of the cutoff switches for the electric motor and for the transmission linkages to the push-pull tube, where it joins the actual mechanism of the gear mechanism in the final gear up and locked and gear down and locked positions.
b) Another adjustment located above the gear down and locked switch involves the mechanism's final position. This adjustment is easy to make since the switch itself can be adjusted without affecting the mechanism's other components. Likewise, there is another indicating switch for the gear up and locked position, which is of no consequence to this investigation.
c) The final adjustment for the mechanism involves changing the length of the lower bellcrank arm using the adjusting screw, an apparently simple process which should not pre-load the bellcrank.

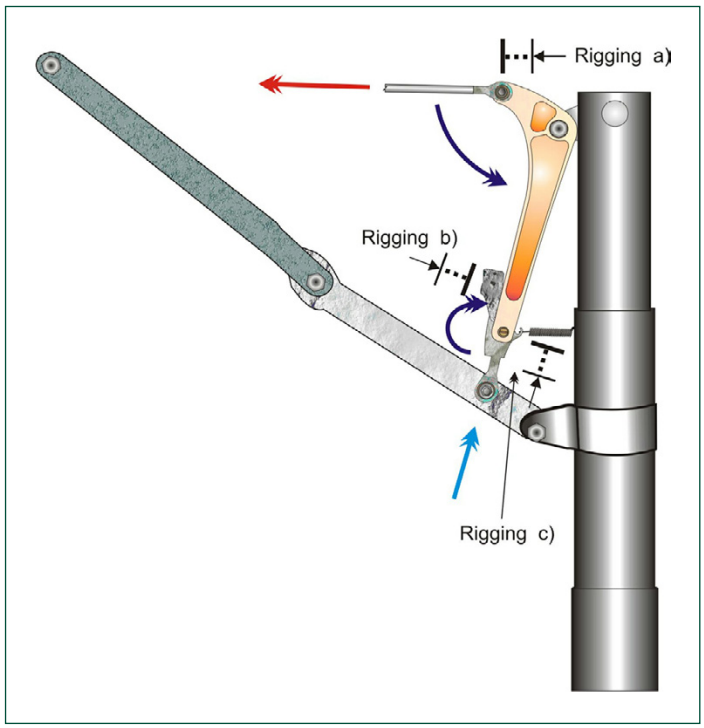

Figure 7. Possible adjustments

An analysis of the motion of the mechanism when close to its final

position (down and locked) and the tests performed by varying the above-mentioned adjustments led to the identification of the two ways in which the bellcrank can be subjected to excess loads and outside operating parameters.

I With adjustment a), the cutoff switch for the motor when extending, beyond its appropriate position, tension is placed on the push-pull tube, and therefore on the upper bellcrank arm. If at the same time the length of the lower bellcrank arm is made excessive using adjustment c), this places a compressive load on the lower bellcrank arm. As a result of either or both loads, the pivot bolt is conditioned for a shear fracture at an intermediate angle between the two arms of the bellcrank.

II A setting contrary to that mentioned above for adjustment c) leaves the lower side link or overcenter with enough clearance at its mechanical stop to allow for the appearance of an oscillatory motion around a neutral axis as a consequence of lateral loads on the leg. This clearance may result from an adjustment of a) as mentioned in the previous paragraph, which would take the gear down switch (adjustment b) to the stop without a fault indication. This oscillatory motion of the overcenter induces loads on the bellcrank, and therefore on the pivot bolt, with results similar to those above and with larger absolute values due to the geometry of the mechanism.

The mechanism must be properly adjusted or calibrated if it is to maintain a suitable geometry in all its configurations and an adequate load distribution within design criteria, without bending and imparting loads on relatively weak components which were designed to move the mechanism and not to absorb landing forces.

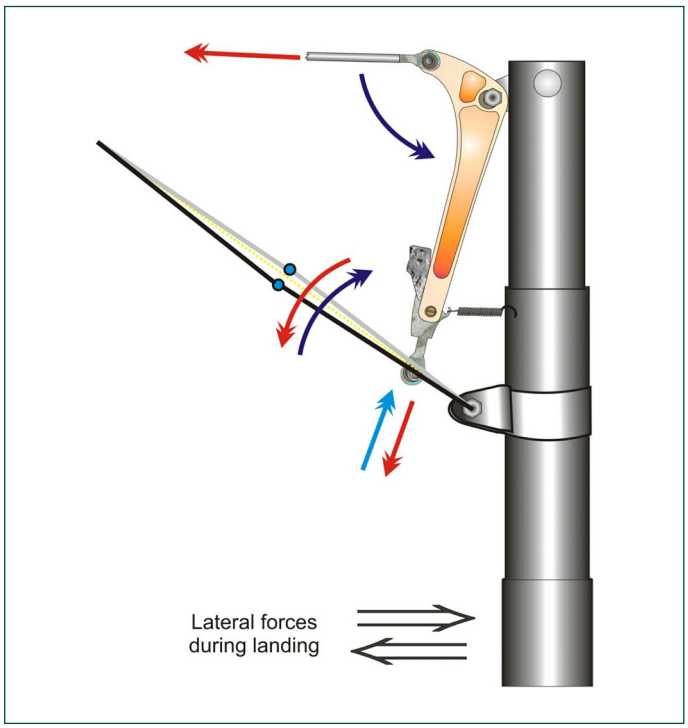

Figure 8. Diagram showing forces on the mechanism

Slack and/or wear in the mechanical adjustments also serve to introduce slight increases in the geometry's angles and configurations, which then allow oscillatory or alternating loads to be imparted on these relatively fragile components. This failure possibility has already been identified by the manufacturer, as evidenced by Supplemental Inspection Documents (SID) 32-10-03 and 32-30-05, as mentioned in Section 1.5, concerning the inspection for excessive slack and wear in the landing gear retraction system (SID 32-10-05), and the inspection of the bellcrank pivot bolt for signs of shear failure (SID 32-10-03).

As in those cases listed in Section 1.11, the incidents involved different operators and even different aircraft share this same gear design, this is an indication that adjustments made to the retraction mechanism, though seemingly simple to understand and effect, are not easy to implement and could result in geometric variations which redistribute loads on the pivot bolt, leading to the collapse of a main gear leg. Likewise the over-center adjustment must not be undertaken as an independent operation, but it must be take like a part of the complete rigging process of the extension-retraction landing gear mechanism.

A safety recommendation is issued in this regard to improve the description for adjusting and rigging the main landing gear retraction-extension system and its spreading and practical application amongst the operators and maintenance centers of Cessna aircrafts affected.

3. CONCLUSION

3.1. Findings

- The possibility of a material failure in the components that fractured in the incident has been ruled out given: 1) the proper material composition of these pieces within design criteria; 2) the metallographic tests performed on these components showing that they failed due to loads in excess of breaking loads; and 3) the absence of pre-existing metallurgical anomalies or defects which may have contributed to or produced the failures.
- The maintenance of these aircraft components was verified to be in accordance with the manufacturer's instructions and, in particular, that SIDs 32-10-03 and 32-30-05 involving the landing gear had been implemented, and that, at the date of the incident, sufficient time remained before the inspections required therein had to be repeated.
- The possibility of an improper assembly or adjustment common to both legs has also been ruled out given the proper operation of the right leg, which presented a normal appearance and whose pivot bolt showed no signs of shear deformation.
- An uncommanded retraction of the LH landing gear leg took place during the aircraft's first landing run for that day, the direct result of the failure of the overcenter lock on the lower side link.
- The landing and the forces resulting from it were normal and did not lead to any special circumstances which may have caused the failure of the left leg.
- The unlocking of the gear from the down position was due to the overload failure of the pivot bolt and of the truss assembly forward clevis ear, which allow for the non-continuity of the locking mechanism about the bellcrank axis of rotation.
- The bends and breaks found allowed for the initial cause of the fault to be identified as the overload and subsequent shear failure of the pivot bolt.
- The overload in the locking mechanism was due either to a pre-load produced during the adjustment process, or to an oscillatory motion resulting from an incorrect

adjustment and slack which, due to the mechanism's geometry, amplified the stresses on the bellcrank.

3.2. Causes

The left landing gear leg collapsed as the result of its locking mechanism losing continuity. The failures in this mechanism were caused by an overload of the affected components. The overload in the mechanism appeared when the landing forces were redistributed, probably due to a variation in the clearance adjustments that was magnified by the locking mechanism's own geometry, and which resulted in a landing gear assembly configuration that was outside design criteria.

4. SAFETY RECOMMENDATIONS

REC 11/08. As a consequence of the reoccurrence of similar events affecting different models of Cessna aircraft that share a main landing gear design, and the variety of operators involved in these cases, it is recommended that the manufacturer Cessna improve the rigging description of the main landing gear extension-retraction system, and its spreading and practical application amongst the operators and maintenance centers of Cessna aircraft affected