AIRCRAFT ACCIDENT REPORT AND EXECUTIVE SUMMARY

			Reference:	**CA18/2/3/10278**	
Aircraft Registration	ZS-III	**Date of Accident**	2 April 2023	**Time of Accident**	1950Z
Type of Aircraft	Cessna C310Q		**Type of Operation**	Private (Part 91)	
Pilot-in-command Licence Type	Commercial Pilot Licence (CPL)		**Age**	37	**Licence Valid** Yes
Pilot-in-command Flying Experience	**Total Flying Hours**		1600	**Hours on Type**	22.9
Last Point of Departure	Upington Aerodrome (FAUP), Northern Cape Province				
Next Point of Intended Landing	Rand Aerodrome (FAGM), Gauteng Province				
Damage to Aircraft	Substantial				

Location of the accident site with reference to easily defined geographical points (GPS readings if possible)

During taxi at FAGM on RWY 35 just beyond RWY 29 intersection at Global Positioning System (GPS) co-ordinates determined to be 26°14'32.04"South, 28° 9'1.87"East, at a field elevation of 5483 feet (ft)

Meteorological Information	Wind direction: 340°; Wind speed: 07kt; Air Temperature: 19°C; Dew Point: 12°C						
Number of People On-board	1+4	**Number of People Injured**	0	**Number of People Killed**	0	**Other (On Ground)**	0

Synopsis

On Sunday evening, 2 April 2023, a pilot and four passengers on-board a Cessna 310Q aircraft with registration ZS-III took off on an hour building flight from Upington Aerodrome (FAUP) in the Northern Cape province to Rand Aerodrome (FAGM) in Gauteng province. The flight was conducted under visual meteorological conditions (VMC) by night and under the provisions of Part 91 of the Civil Aviation Regulations (CAR) 2011 as amended.

Prior to departure at FAUP, a pre-flight inspection was conducted with no anomalies detected. The aircraft was refuelled with 409 litres of Avgas 100LL, which brought the total fuel capacity to 540 litres. The pilot and the passengers took off at approximately 1730Z. The pilot selected the landing gear to 'down' position during final approach for Runway (RWY) 35 at FAGM; he also noted the three green lights (which indicated that all gears were down and locked) prior to landing. During the landing roll, the left wing lowered and, shortly thereafter, the left propeller and the wing made contact with the ground. The aircraft veered off to the left and came to rest 60 metres (m) from the runway edge. The aircraft was substantially damaged. No injuries were reported during the accident.

The investigation revealed that the left landing gear collapsed because it unlocked from the 'down' position due to overload failure of the bell-crank axis mechanism. The collapse of the left main landing gear further caused damage to the push-pull tube and the bell-crank's adjusting screw.

Probable Cause/s

The left main landing gear collapse was due to an overload failure of the locking mechanism as a result of either the pre-load produced during the adjustment process, or an oscillatory motion that resulted from an incorrect adjustment (looseness) due to the mechanism's geometry that amplified the stress on the bell-crank.

Contributory Factors

- Incorrect rigging adjustment conducted during maintenance.

SRP Date	12 September 2023	Publication Date	11 January 2024

Occurrence Details

Reference Number	**:** CA18/2/3/10278
Occurrence Category	**:** Category 1
Type of Operation	**:** Private (Part 91)
Name of Operator	**:** Fundiflex Aviation
Aircraft Registration	**:** ZS-III
Aircraft Make and Model	**:** Cessna C310Q
Nationality	**:** South African
Place	**:** At FAGM on Runway 35
Date and Time	**:** 2 April 2023 at 1950Z
Injuries	**:** None
Damage	**:** Substantial

Purpose of the Investigation

In terms of Regulation 12.03.1 of the Civil Aviation Regulations (CAR) 2011, this report was compiled in the interest of the promotion of aviation safety and the reduction of the risk of aviation accidents or incidents and not to apportion blame or liability.

All times given in this report are Co-ordinated Universal Time (UTC) and will be denoted by (Z). South African Standard Time is UTC plus 2 hours.

Investigation Process

The Accident and Incident Investigations Division (AIID) of the South African Civil Aviation Authority (SACAA) was notified of the occurrence on 2 April 2023 at 2000Z. The occurrence was classified as an accident according to the CAR 2011 Part 12 and ICAO STD Annex 13 definitions. Notifications were sent to the State of Registry, Operator, Design and Manufacturer in accordance with the CAR 2011 Part 12 and ICAO Annex 13 Chapter 4. The states did appoint an accredited representative and/or advisor. The investigator did not dispatch to the site for this accident.

Notes:

1. *Whenever the following words are mentioned in this report, they shall mean the following:*
   Accident — this investigated accident
   Aircraft — the Cessna C310Q involved in this accident.
   Investigation — the investigation into the circumstances of this accident
   Pilot — the pilot involved in this accident.
   Report — this accident report

2. *Photos and figures used in this report were taken from different sources and may have been adjusted from the original for the sole purpose of improving clarity of the report. Modifications to images used in this report were limited to cropping, magnification, file compression; or enhancement of colour, brightness, contrast; or addition of text boxes, arrows, or lines.*

Disclaimer

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Abbreviation	Description
º	Degrees
ºC	Degrees Celsius
AIID	Accident and Incident Investigations Division
C of R	Certificate of Registration
CAR	Civil Aviation Regulations
CPL	Commercial Pilot Licence
CRS	Certificate of Release to Service
FAGM	Rand Airport
FAUP	Upington Airport
ft	Feet
GPS	Global Positioning System
hPa	Hectopascal
kt	Knots
l	Litres
m	Metres
METAR	Meteorological Aerodrome Report
MHz	Megahertz
NDB	Non-Directional Beacon
RA	Resolution Advisory
RAV	Read Aviation
RWY	Runway
SACAA	South African Civil Aviation Authority
SAWS	South African Weather Service
SID	Supplementary Inspection Documents
QNH	Altitude Above Mean Sea Level
VMC	Visual Meteorological Conditions
VOR	Very High Frequency Omni-Directional Range
Z	Zulu (Term for Universal Co-ordinated Time - Zero Hours Greenwich)

1. FACTUAL INFORMATION

1.1. History of Flight

1.1.1. On Sunday morning, 2 April 2023, a pilot and four (4) passengers reported to Hangar Alpha (A) at Wonderboom Aerodrome (FAWB) to collect the hire-and-fly Cessna 310Q aircraft with registration ZS-III for a flight to Upington Aerodrome (FAUP) in the Northen Cape with the intention to land at Rand Aerodrome (FAGM) in Gauteng province. The pilot reported that he conducted a pre-flight inspection, as well as uplifted 272 litres of Avgas 100LL (fuel). At approximately 0900Z, the aircraft departed FABW for FAUP with the four passengers on-board. The flight to FAUP was uneventful.

1.1.2. According to the flight folio, the aircraft was flown between FAUP and Alexander Bay Aerodrome (FAAB) in the same province during the course of the day. Later, the aircraft was prepared for a return flight to FAGM where it was to be parked at the owner's hangar.

1.1.3. On the same night, the pilot and four passengers took off on a private flight from FAUP to FAGM. The flight was conducted under visual meteorological conditions (VMC) by night and under the provisions of Part 91 of the Civil Aviation Regulations (CAR) 2011 as amended.

1.1.4. Prior to departure from FAUP, a pre-flight inspection was conducted, and no anomalies were detected. The aircraft was refuelled with 409 litres of Avgas 100LL, which brought the total fuel capacity to 540 litres. The aircraft took off at approximately 1730Z. Upon reaching FAGM, the pilot selected the landing gear to the 'down' position during final approach for landing on Runway (RWY) 35. The pilot noted the three green lights indicating that all gears were down prior to landing. During the landing roll, the left wing lowered and, shortly thereafter, the left propeller and the (left) wing made contact with the runway and the aircraft veered off to the left of the runway and came to rest 6 metres (m) from the runway edge between RWY 11/29 and the taxiway facing south-west. The aircraft was substantially damaged during the accident; however, no person was injured.

1.1.5. The accident occurred on RWY35 at Global Positioning System (GPS) co-ordinates determined to be 26º14'32.04" South 28º 9'1.87" East, at a field elevation of 5483 feet (ft).

Figure 1: The view of the accident site at FAGM. (Source: Google Earth)

1.2. Injuries to Persons

Injuries	Pilot	Crew	Pass.	Total On-board	Other
Fatal	-	-	-	-	-
Serious	-	-	-	-	-
Minor	-	-	-	-	-
None	1	-	4	5	-
Total	**1**	**-**	**4**	**5**	**-**

Note: Other means people on the ground.

1.2.1. No occupants on-board the aircraft were injured.

1.3. Damage to Aircraft

1.3.1. The aircraft sustained substantial damage to the left main landing gear, fuselage and left engine propeller blades.

Figure 2: The aircraft as it came to rest. (Source: Operator)

1.4. Other Damage

1.4.1. No other damage was reported.

1.5. Personnel Information

Nationality	South African	Gender	Male	Age	37
Licence Type	Commercial Pilot Licence (CPL) Aeroplane				
Licence Valid	Yes	Type Endorsed	Yes		
Ratings	Instrument, Instructor Grade II and Test Pilot Class 2				
Medical Expiry Date	30 June 2023				
Restrictions	None				
Previous Accidents	None				

Note: Previous accidents refer to past accidents the pilot was involved in, when relevant to this accident.

Flying Experience:

Total Hours	1600
Total Past 24 Hours	8.2
Total Past 7 Days	8.2
Total Past 90 Days	40
Total on Type Past 90 Days	12.6
Total on Type	22.9

1.5.1. The pilot had a Commercial Pilot Licence (CPL) Aeroplane which was initially issued on 29 June 2015. His CPL renewal was issued by the Regulator (SACAA) on 24 November 2022 with an expiry date of 31 December 2023. The pilot also had a Class 1 medical certificate that was issued on 2 June 2022 with an expiry date of 30 June 2023. The aircraft type was endorsed on his licence. The pilot accumulated a total of 1600 flying hours of which 22.9 hours were on the aircraft type. The pilot also had a Grade 2 instructor rating and a Class 2 rating for instrument and test pilot.

1.6. Aircraft Information

1.6.1. The information below is an extract from the Pilot's Operating Handbook (POH)

The Cessna 310 is an American four-to-six-seat, low-wing, twin-engine produced by Cessna between 1954 and 1980. It was the first twin-engine aircraft that Cessna put into production. The aircraft is powered by two Rolls Royce Continental IO-470-VO engines with a maximum take-off weight of 5,300lb (2,400kg). The engines use an Avgas 100-LL fuel type. The fuel system for the aircraft consisted of four fuel tanks: two 51 US gallon (193 litre(l)), main fuel tanks in the wings and, two 20.5 US gallon (78 litre) auxiliary fuel tanks in the outboard wingtip-mounted on each wing.

A pair of fuel selector switches, mounted on the cockpit floor, operated a fuel selector valve immediately outboard of each engine, which allowed each engine to receive fuel from its respective main or auxiliary tank, or to cross-feed fuel from the other main tank. The cross-feed, which was intended for emergency use, was the only interconnection between the left and right fuel systems. The aircraft 's landing gear type is a full retractable tri-cycle landing gear. The aircraft had been fitted with two McCauley 3AF32C87-NIO three-bladed, constant speed propellers.

Airframe:

Manufacturer/Model	Cessna Aircraft Company/ Cessna310Q	
Serial Number	C310Q-0255	
Year of Manufacture	1972	
Total Airframe Hours (At Time of Accident)	2874.2	
Last Inspection (Date & Hours)	3 August 2022	2823.3
Hours Since Last Inspection	50.9	
CRS Issue Date	3 August 2022	
C of A (Issue Date & Expiry Date)	9 November 2022	8 November 2023
C of R (Issue Date) (Present Owner)	30 September 2019	
Type of Fuel Used	Avgas 100-LL	
Operating Category	Part 91	
Previous Accidents	None	

Note: Previous accidents refer to past accidents the aircraft was involved in, when relevant to this accident.

Engine 1 (Left):

Manufacturer/Model	Continental IO-470-VO
Serial Number	149267-72-V0
Part Number	I0-470-VO
Hours Since New	2823.3
Hours Since Overhaul	345.82

Propeller 1 (Left):

Manufacturer/Model	McCauley 3AF32C87-NIO
Serial Number	710001
Part Number	3AF32C87-NIO
Hours Since New	2823.3
Hours Since Overhaul	345.82

Engine 2 (Right):

Manufacturer/Model	Continental IO-470-VO
Serial Number	149037-70-V0
Part Number	I0-470-VO
Hours Since New	2823,3
Hours Since Overhaul	345.82

Propeller 2 (Right):

Manufacturer/Model	McCauley 3AF32C87-NIO
Serial Number	705235
Part Number	3AF32C87-NIO
Hours Since New	2823.3
Hours Since Overhaul	345.82

1.6.2. The aircraft maintenance records, which include the airframe, engines, propeller, flight folio and mandatory periodic inspection (MPI) documents were reviewed. According to the preliminary reviews, the aircraft was maintained in accordance with the manufacturer's prescribed procedures. All manufacturer's Service Letters (SL), Service Bulletins (SB), Technical Service Instructions (TSI), Supplementary Inspection Document (SID), etc. were adhered to during maintenance by both the aircraft maintenance organisation (AMO) and the owner to ensure the aircraft's airworthiness.

1.6.3. The aircraft was issued a Certificate of Airworthiness (C of A) by the Regulator on 9 November 2022 with an expiry date of 8 November 2023. The C of A was issued after the MPI was conducted by the AMO. Thereafter, the AMO issued the Certificate of Release to Service (CRS) on 3 August 2022 at 2823.3 airframe hours with an expiry date of 3 August 2023 or at 2923.3 airframe hours, whichever comes first. The aircraft had a total of 2874.2 airframe hours at the time of the accident.

1.6.4 **The aircraft landing gear system:**

The information below is an extract from the POH.

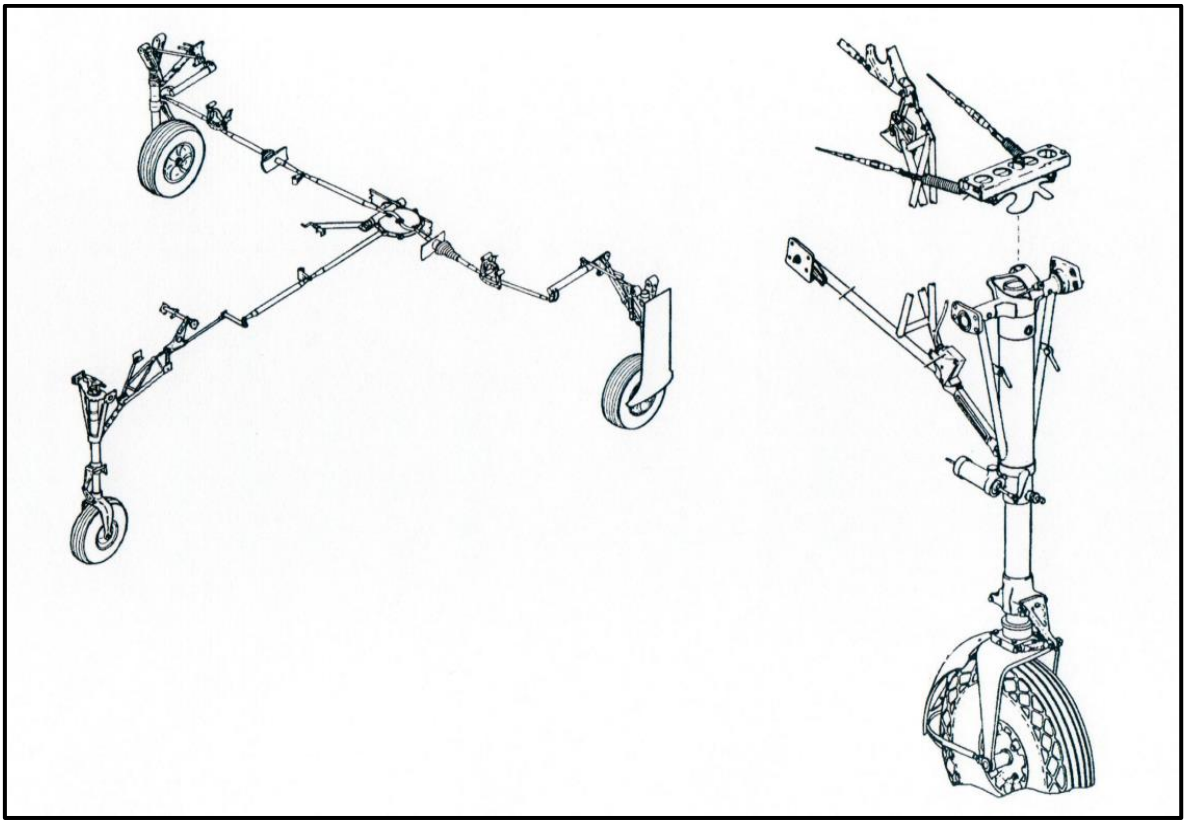

Diagram 1: Schematic of the landing gear system.

The landing gear system is electrically operated and fully retractable which incorporates a steerable nosewheel. To help prevent accidental retraction, an automatic safety switch on the LEFT shock strut prevents retraction if the weight of the airplane is sufficient to compress the strut. The landing gear is operated by a switch, which is identified by a wheel-shape knob. The switch position is: UP, OFF and DOWN. To operate the gears, pull out on the switch knob and move to desired position. The landing gear position lights are provided, one above and three below the landing gear switch. The upper light is amber and will always illuminates when the landing gear is fully retracted. The three lower lights are green and will illuminate when each gear is fully extended and locked. When the gear up light and gear down lights

are not illuminated, the landing gear is in an intermediate position. The lights are push-to-test type with rotatable dimming shutters.

Landing gear warning horn is controlled by the throttles and will sound an intermittent note if either throttle is retracted below approximately 12 inches Hg. Manifold pressure with the gear up. The warning horn is also connected to the UP position of the landing gear switch and will sound if the switch is placed in the UP position while the airplane is on the ground. The landing gear system is equipped with an emergency retraction extension system. A hand crank (pump lever) for manually lowering the landing gear is located just below the right front edge of the pilot's seat.

1.6.5 *According to the Mandatory Periodic Inspection work pack as provided by the AMO, the aircraft landing gear rigging inspection was conducted according to Figure 2-8A of the aircraft maintenance manual.*

1.7. Meteorological Information

1.7.1. The weather information below was obtained from the Meteorological Aerodrome Report (METAR) that was issued by the South African Weather Service (SAWS), recorded at FAOR on 2 April 2023 at 2000Z. FAOR is situated 8 nautical miles (nm) north-east of FAGM.

Wind Direction	340°	Wind Speed	06kt	Visibility	C9999
Temperature	19°C	Cloud Cover	FEW	Cloud Base	3500ft
Dew Point	12°C	QNH	1024hPa		

1.8. Aids to Navigation

1.8.1. The aircraft was equipped with standard navigational equipment as approved by the Regulator. There were no records indicating that the navigational equipment was unserviceable prior to the accident.

1.9. Communication

1.9.1. The aircraft was equipped with a standard communication system as approved by the Regulator. There were no recorded defects with the communication system prior to the accident.

1.10. Aerodrome Information

1.10.1. The accident occurred at FAGM Runway 35 during the landing roll.

Aerodrome Location	Gauteng Province
Aerodrome Status	Licensed
Aerodrome GPS coordinates	26º14'31.37"South, 028°09'04.88"East
Aerodrome Elevation	5 483ft (1,671m)

Runway Headings	17/35	11/29
Dimensions of Runway Used	1579m × 15m	1 197m × 15m
Heading of Runway Used	35	
Surface of Runway Used	Asphalt	
Approach Facilities	RAV VOR/DME117.70MHz, RD NDB 307.50MHz RA NDB 338.00KHz	
Tower Radio Frequency	118.7 MHz	

Note: The air traffic control service is in operation between 0500Z and 1900Z.

1.10.2 The information below is published in the FAGM website: https://www.randairport.co.za/information

- *Rand Airport is known for hot & extreme conditions and its relatively short runways.*
- *The density altitude can be as high as 7 900ft when the operational air traffic (OAT) is at 30ºC.*
- *Urban sprawl surrounding the airport means there are not many forced landing fields or areas.*
- *Rand Airport experiences a lot of wind shear particularly on approach for Runway 35.*
- *High-tension power lines on approach to Runway 17 are marked with red and white spheres.*
- *High trees on approach to Runway 17.*
- *Be careful of the FAJS CTR when approaching runway 29 or departing Runway 11.*

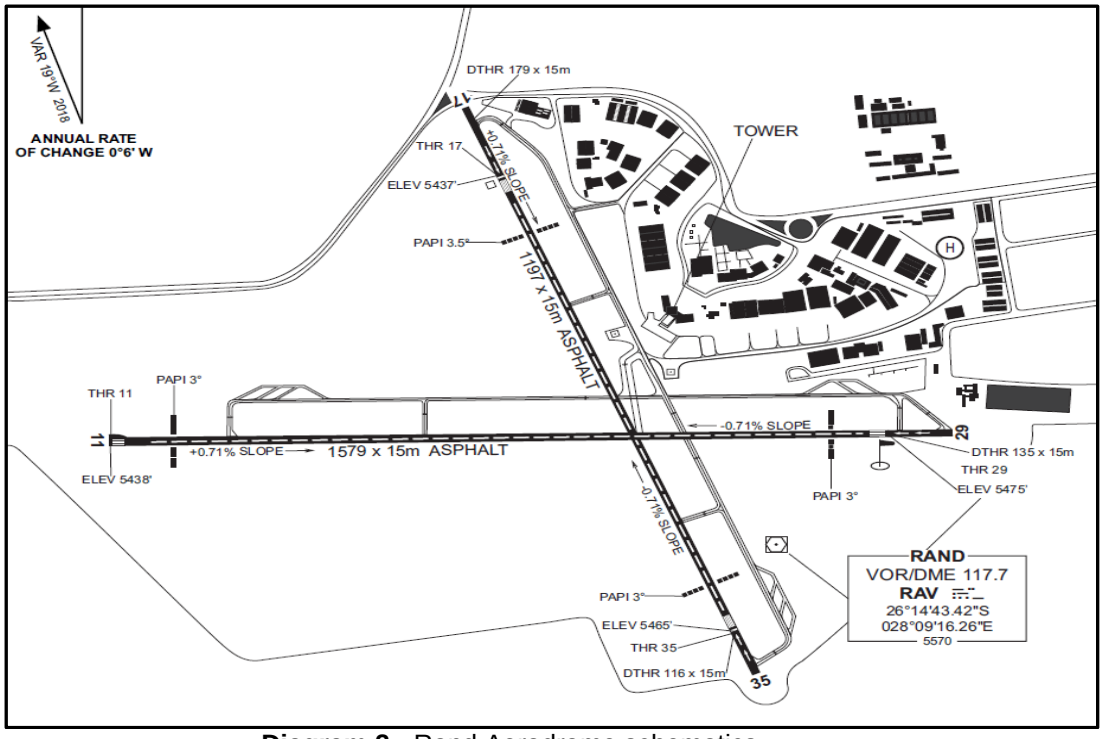

Diagram 2: Rand Aerodrome schematics.

1.11. Flight Recorders

1.11.1. The aircraft was not equipped with a flight data recorder (FDR) or a cockpit voice recorder (CVR), nor was it required by regulation to be fitted to the aircraft type.

1.12. Wreckage and Impact Information

1.12.1. The accident occurred during the landing roll on RWY35 after the intersection of RWY29. Propeller strike marks on the runway surface swerved towards the left; this was consistent with the aircraft's left wing and components that scrapped the surface as it veered off. The aircraft stopped on the left side of the runway with the left wing in contact with the ground.

1.12.2. The following were observed post-accident:

- There were two lines (scrape marks) in the direction of and directly proportional to the wing tip position and the left propeller. The wing tip and the propeller blades sustained damage as a result of contact with the ground.

- The wing attachment root outer skin was also damaged.

- The radio antenna and rear bottom structure were damaged due to scrapping on the runway surface.

Figure 3: Damage sustained by the propeller.

- The left main landing gear collapsed towards the retraction fold. The left landing gear door sustained damage when it scraped against the runway surface.

Figure 4: The collapsed left main landing gear.

- The cockpit assessment revealed that the aircraft was shut down after the accident. The landing gear lever was set to 'down' position. When the master switch was selected to 'on' position, only two landing gear lights (right and the nose) turned green. This was because both the nose and the right landing gears were selected to 'down and locked' position (these lights came on during testing post-accident).

Figure 5: The cockpit landing gear controls and indicators.

- The left wing was raised by the recovery team post-accident to level the aircraft and to conduct further observations and assessment of the damage. Figure 6 shows the torque tube with the damaged push-pull tube's connecting eye-end. The retraction and extension link (push-pull tube) had bent (damage) which was consistent with compression forces closer to the connection point towards the torque tube.

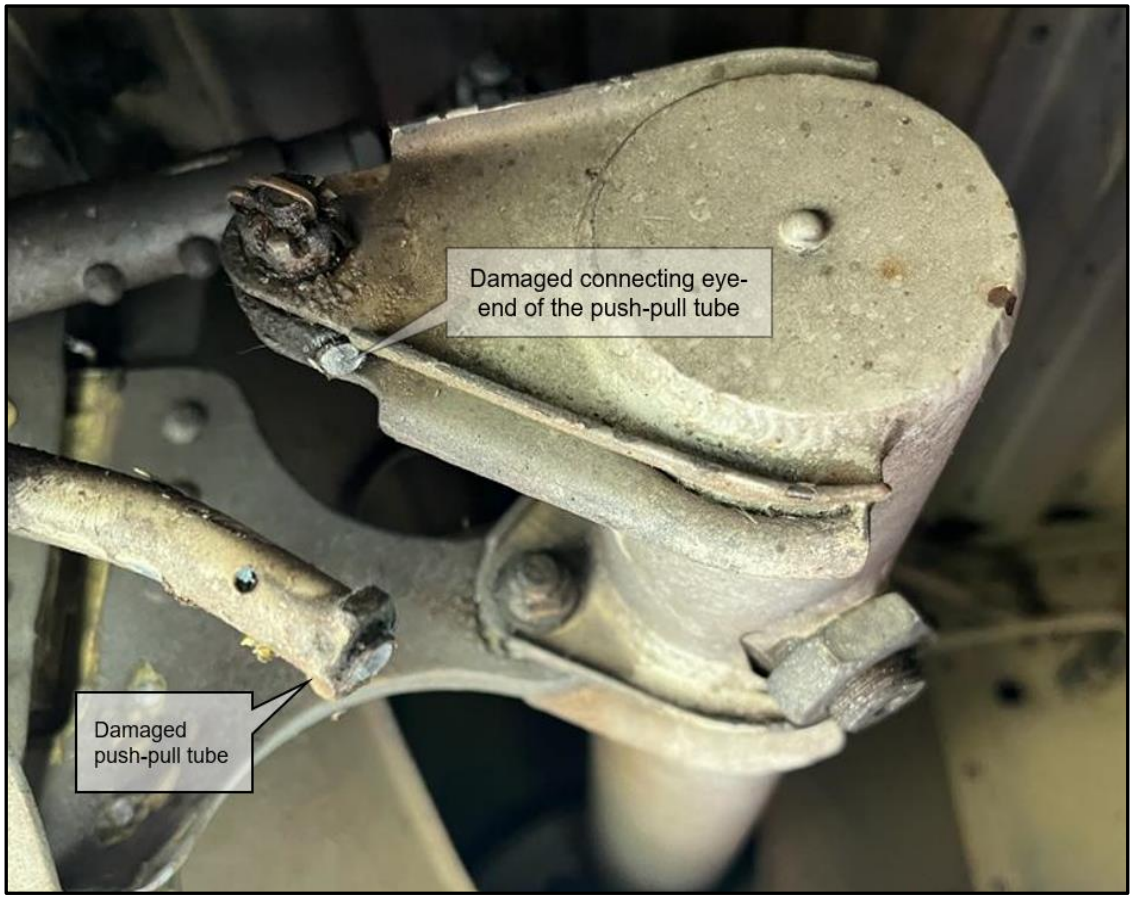

Figure 6: The failed push-pull tube on the left main landing gear torque tube.

- Figure 7 shows the left main landing gear, in extended position, support steel bar on the upper and lower side link to keep it in the locked position. The bell-crank bottom adjusting screw's connecting eye-end broke off during the accident sequence. The damage exhibit instantaneous failure which is likely to have resulted from the tensile stress (forces).

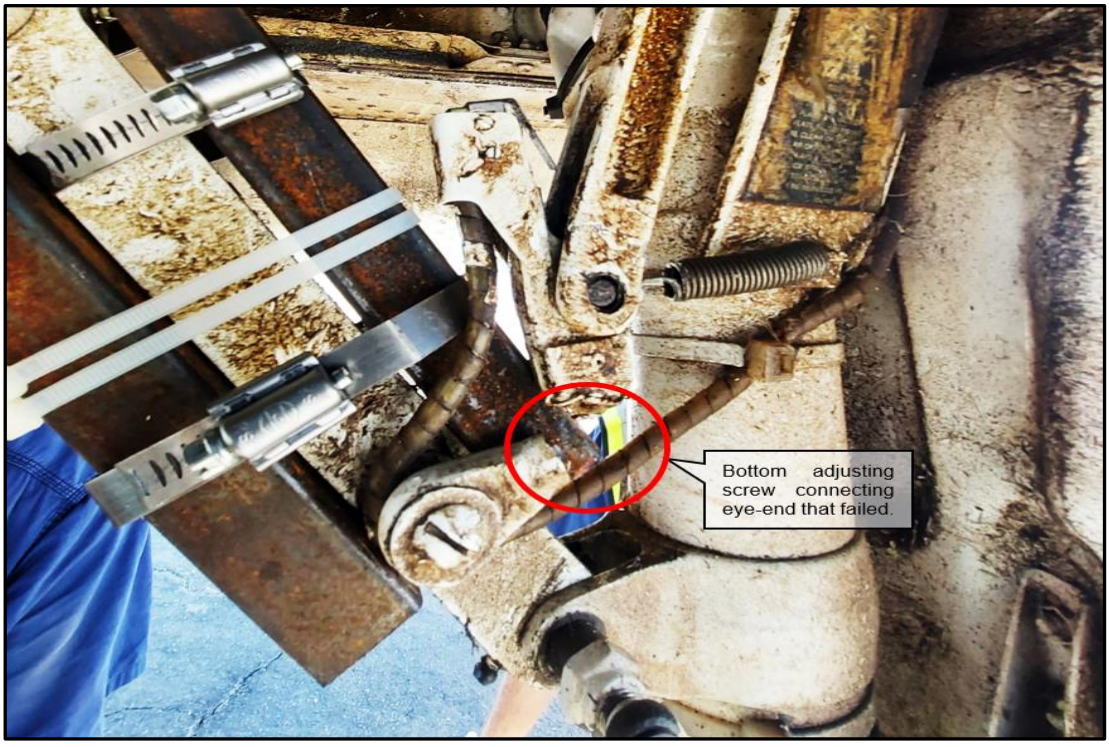

Figure 7: The left main landing gear supported with steel bars and the damaged bottom adjusting screw connecting eye-end.

- Both landing gears' lower link attachment bolts were sluggish. The bolts displayed a significant amount of looseness.

1.12.3 The aircraft elevator was damaged during the accident sequence.

Figure 8: The damaged left elevator.

1.13. Medical and Pathological Information

1.13.1. None.

1.14. Fire

1.14.1. There was no pre- or post-accident fire.

1.15. Survival Aspects

1.15.1. The accident was considered survivable as damage was limited to the left main landing gear. The speed at which the aircraft was travelling during the landing roll was minimal and did not subject the aircraft to damage in the cockpit and the cabin areas. All occupants were restrained by their seat belts during the accident.

1.16. Tests and Research

1.16.1 The aircraft was recovered by an AMO in FAWB. During recovery, it was discovered that the left main landing gear retracted uncommanded and the push-pull tube that links the torque tube to the bell crank and the bottom adjustable screw eye-end failed. Further inspection by the AMO revealed that both attachment bolts on each main landing gears were loose and exhibited excessive slackness.

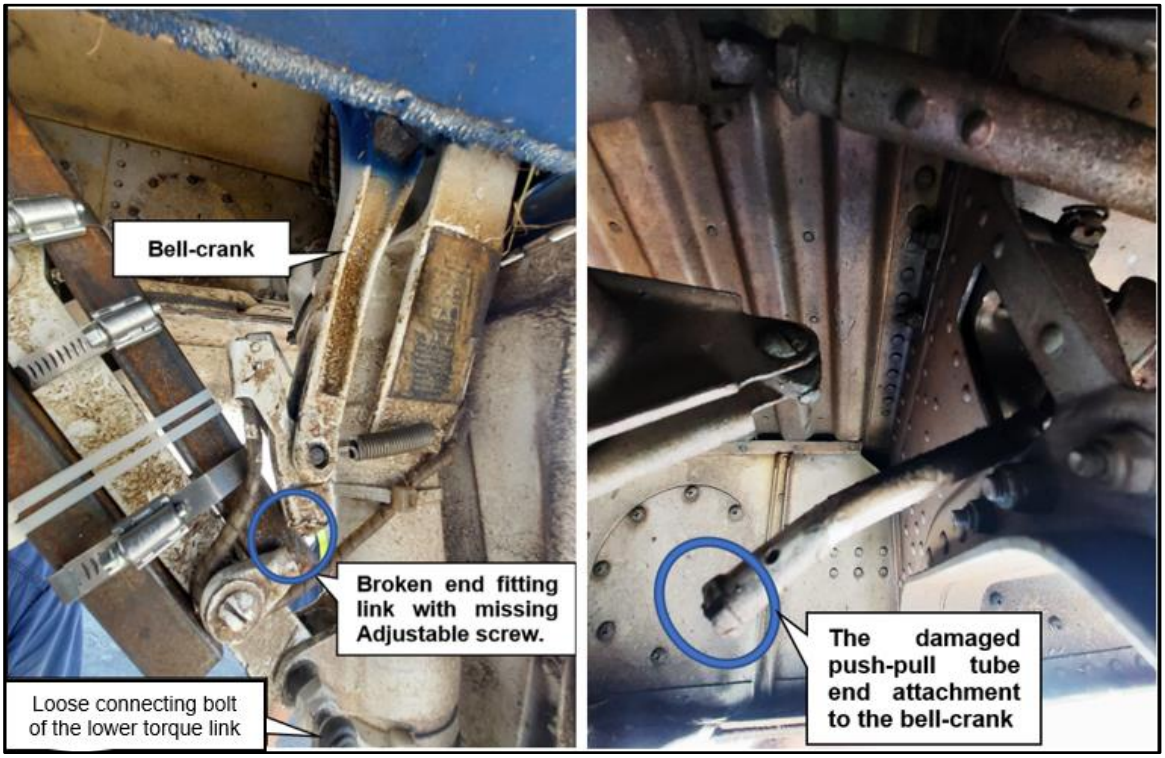

Figure 9: The damaged components – bottom end fitting link (left) and bell-crank connecting push-pull tube (right).

- The damage on the push-pull tube (bent) are likely due to compression force.

Figure 10: The damaged components.

- Figure 9 exhibits instantaneous failure which was likely caused by overload forces during an uncommanded landing gear retraction during the slow landing roll. This is also evidence by the peeling off of the paint on the side where compression bending occurred. The eye-end attachment point that connects to the torque tube had broken off.

Figure 11: Damage on the eye-end push-pull tube.

Figures (11 and 12) show the bottom adjusting screw arm with the failed eye-end attachment. The damage exhibits an instantaneous failure which is likely to have resulted from overload forces that occurred during an uncommanded landing gear retraction.

Figure 11 shows the damage on the bottom adjusting screw below the adjusting nut that remained and still attached to the locking wire.

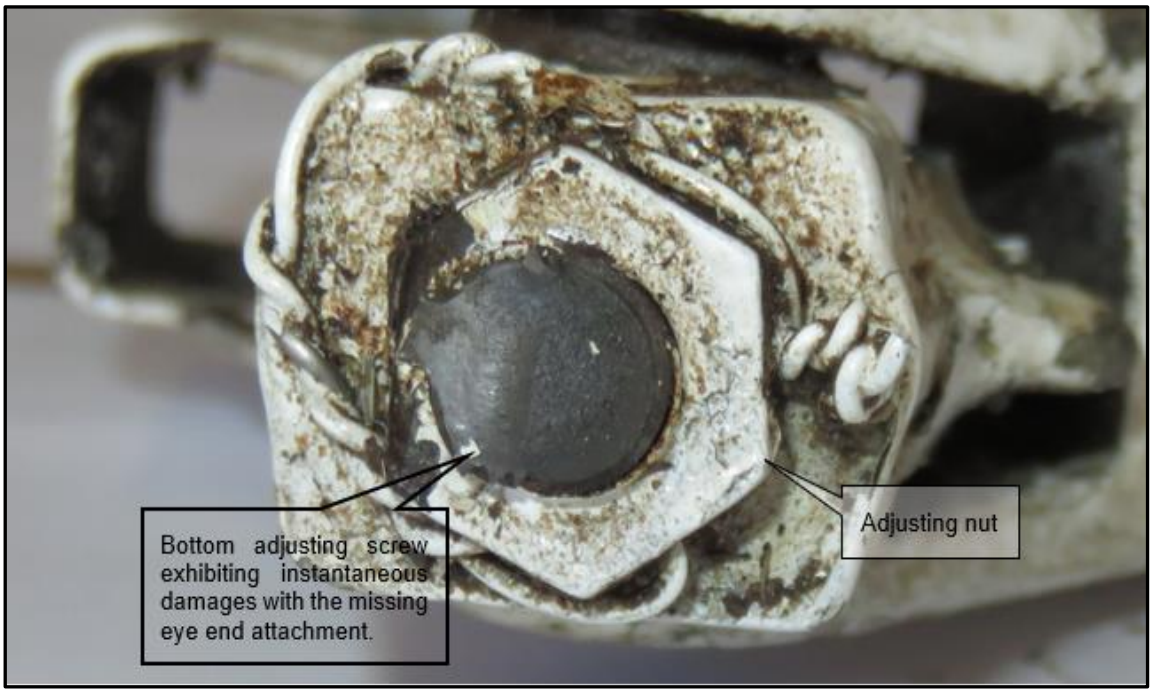

Figure 12: The damage on the bottom adjusting screw bolt attachment eye-end.

The failure indicates an instantaneous mode which resulted in the paint peeling off on both the adjusting nut inner part and the locking wire. This was likely caused during the excessive force which resulted from the retracting landing gear that was in ‘down and locked’ landing gear mode.

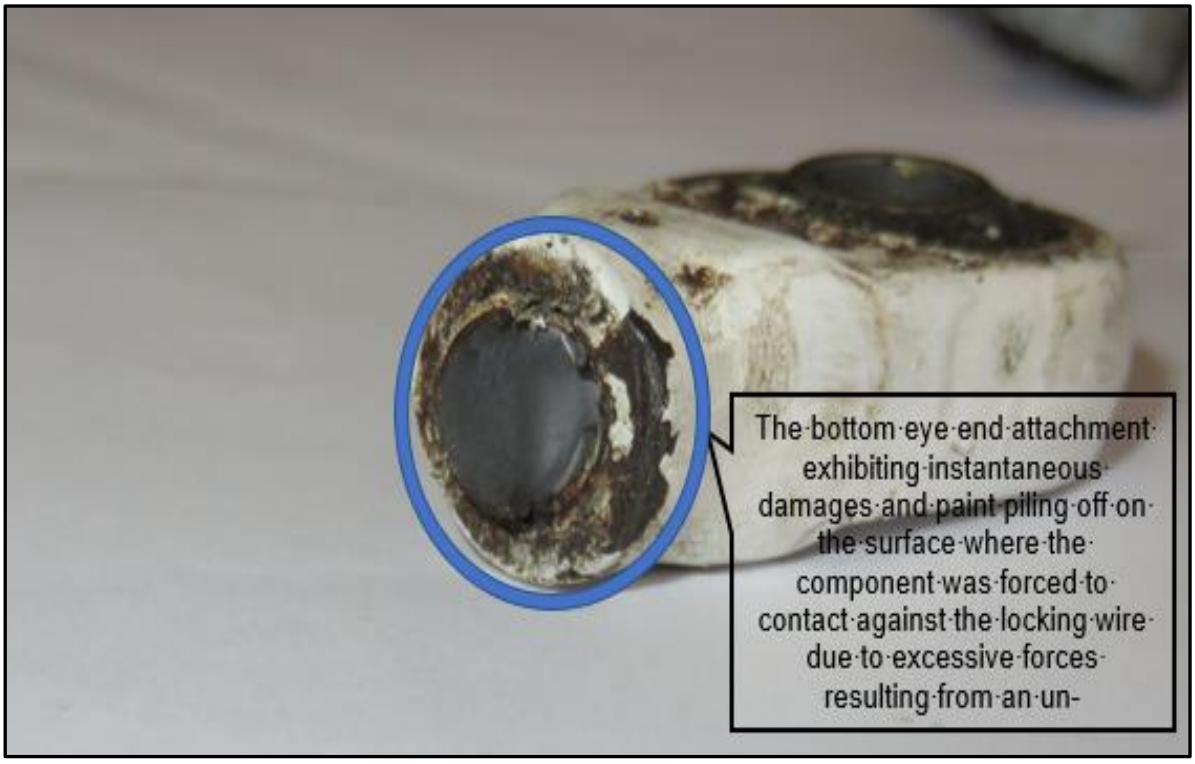

Figure 13: The bottom eye-end attachment.

1.16.2 Further research revealed similar occurrences on other aircraft models.

The information below is an extract from the Report IN-017/2006 Addenda Bulletin 3/2008

An investigation report relating to a Cessna 421-B which had a similar landing gear structure was studied and considered. According to the report similar to this investigation, the left main landing gear leg was almost completely retracted inside the wheel bay well with some pieces broken off from the actuating mechanism. Consequently, the aircraft had fallen towards the left side, resulting in damages along the bottom of the fuselage and left wing, especially the left flaps as well as in a bent left wingtip. It was also noted that the tips of the propeller 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 runway several times.

<u>Description of landing gear system</u>

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.

Diagram 3 shows 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 components most relevant to this accident. Indicated in the red circles highlights the breaks discovered, to be addressed later.

Looking at the left leg only (Diagram 3), the operation of the system to retract the gear would require the electrical motor which turns such that the push-pull tube would move towards the leg, pushing the bell-crank, to which it is attached. The push-pull tube makes the bell-crank rotate and push on the pivot bolt, which is located in the truss assembly.

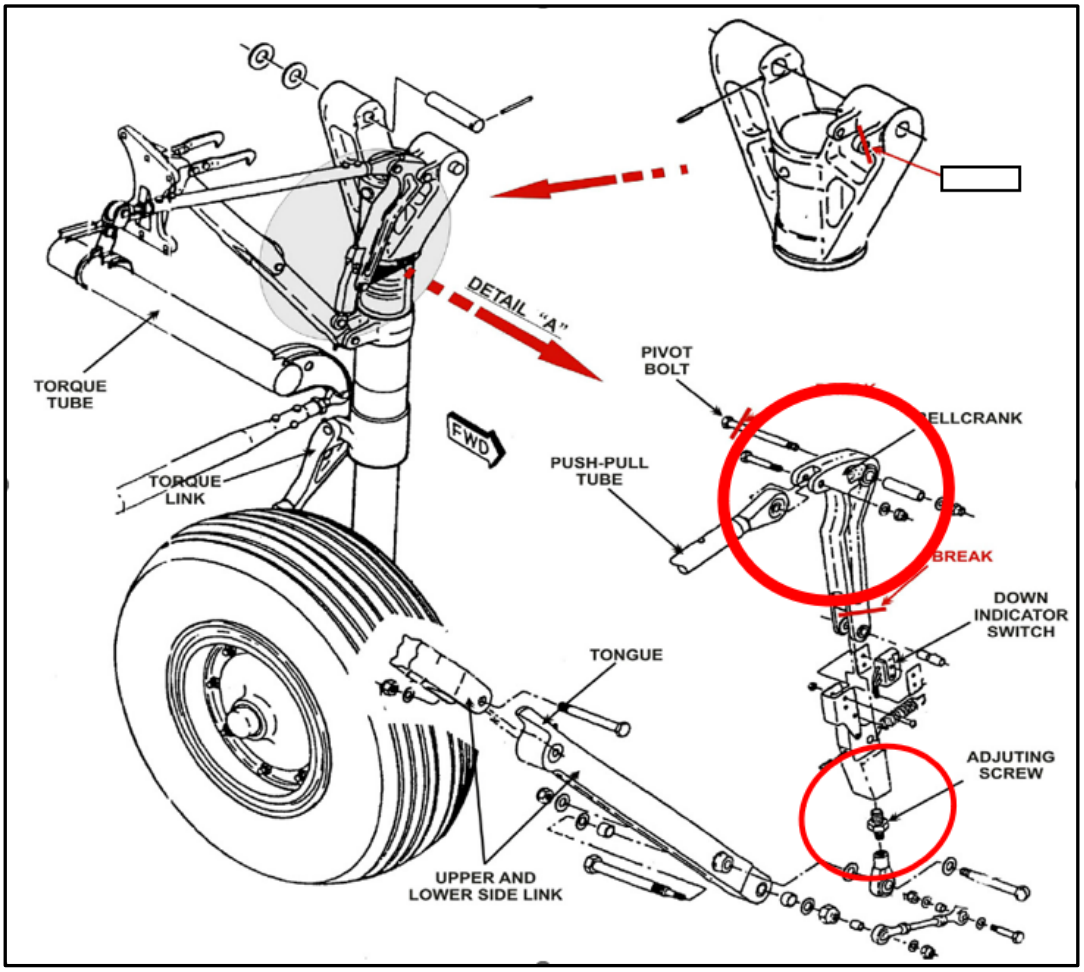

Diagram 3: The schematic of the left landing gear push-pull tube and the bottom end fitting with an adjustable screw.

The push generates torque in the pivot bolt and to retract the gear assembly (leg rotates towards the fuselage). Simultaneously, the rotation of the bell-crank 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 over-centre of the lower side link, to which it is attached. This connection is also hinged and goes through the adjusting screw which is attached to the end fitting and the side brace lock link. The pulling on this causes the lower side link to fold upward, allowing the leg to rotate towards the fuselage.

The side link assembly consists of two arms, upper and lower, hinged at the centre 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 take-offs and landings. The geometric arrangement is such that when the gear is lowered, the side link extends and is locked in place by the bell-crank, which forces its hinge to extend past the imaginary line that would join the ends of its arms. This lock, known as the over-centre, is complete by means of a tab at the hinged end of the lower side link of the assembly, shown in Diagram 3 which limits the maximum possible value of the over-centre (the side link assembly is sometimes called the over-centre) and doubles as a mechanical stop which keeps the assembly from bending downward.

The position of the over-centre is regulated by adjusting the length of the hinged lower bell-crank 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 side link assembly reaches the

over-centre, the lower hinged bell-crank arm is straight and in its maximum length position.

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 over-centre position.

Analysis of the uncommanded retraction process

The geometric layout of the main gear such that when the gear is in the proper "down and locked" position any vertical and lateral load 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, 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.

Abnormal conditions must have, therefore, existed in the extending and locking mechanism of the left-hand or right-hand gears which resulted in the presence of such loads on the mechanism's components.

Failure Sequence

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

The direction of the force causing the failure of the bell-crank 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 bell-crank, 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 bell-crank lower arm, seemed to be caused by forces and torques perpendicular to the plane in which the bell-crank itself moves during extension-retraction, as indicated by the large lateral bending component.

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

- *The damaged starts with a single shear of the bell-crank pivot bolt (in every case the failure takes place between the rear trunnion clevis ear and the bell-crank).*
- *The mechanism maintains its shape and allows the leg to lock, since the pivot bolt is still performing its function, through load is placed on one sole trunnion clevis ear.*
- *Lateral forces appear on the bell-crank as a consequence of the loading asymmetry from the bell-crank pivot bolt on the front clevis ear.*
- *The adjusting screw or the lower bell-crank arm clevis ears bend considerably.*
- *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 bell-crank arm, at which point (4 and 5) continuity is lost in the leg locking mechanism.

- *The main landing gear leg collapses slowly, even if there is not a high load on that leg at the same time.*
- *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 inlocks, 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 over centre position on the lower side link support the failure sequence described.

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 over centre (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.

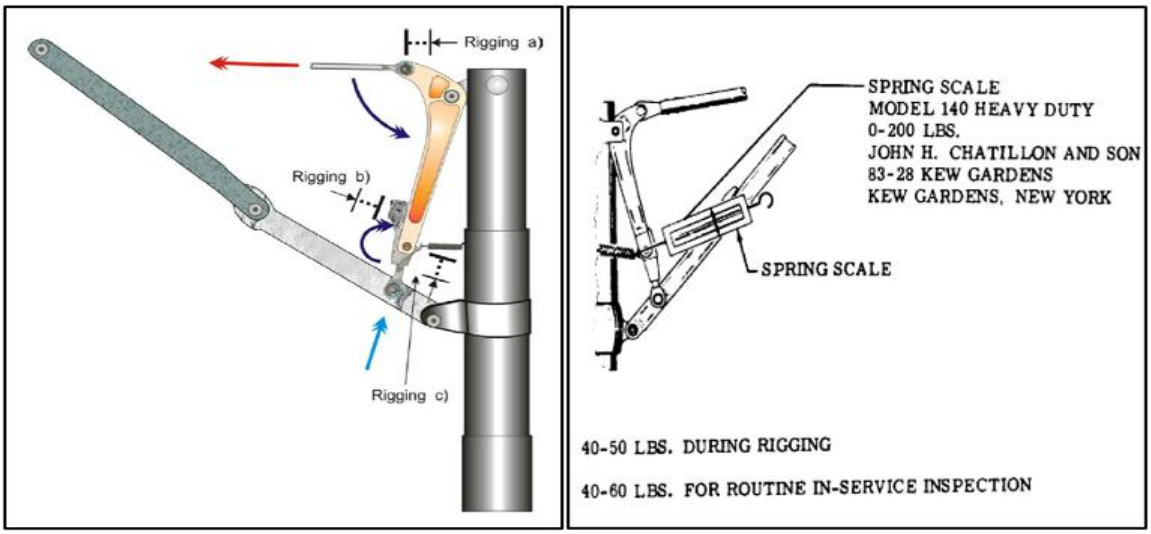

Illustration 1: Shows possible adjustments points during rigging.

a) *The first involves the positioning of the cut-off 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 position.*

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 bell-crank arm using the adjusting screw, an apparently simple process which should not pre-load the bell-crank.*

An analysis of the motion of the mechanism when close to its final position (down and locked) and the test performed by varying the above-mentioned adjustments led to the identification of the two ways in which the bell-crank can be subjected to excess loads and outside operating parameters.

I. *With adjustment a), the cut-off switch for the motor when extending, beyond its appropriate position, tension is placed on the push-pull tube, and therefore on the upper bell-crank arm. If at the same time the length of the lower bell-crank arm is made excessive using adjustment c), this places a compressive load on the lower bell-crank 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 bell-crank.*

II. *A setting contrary to that mentioned above for adjustment c) leaves the lower side link or over centre 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 over centre induces loads on the bell-crank, and therefore on the pivot bolt, with results similar to those above and with large absolute values due to the geometry of the mechanism.*

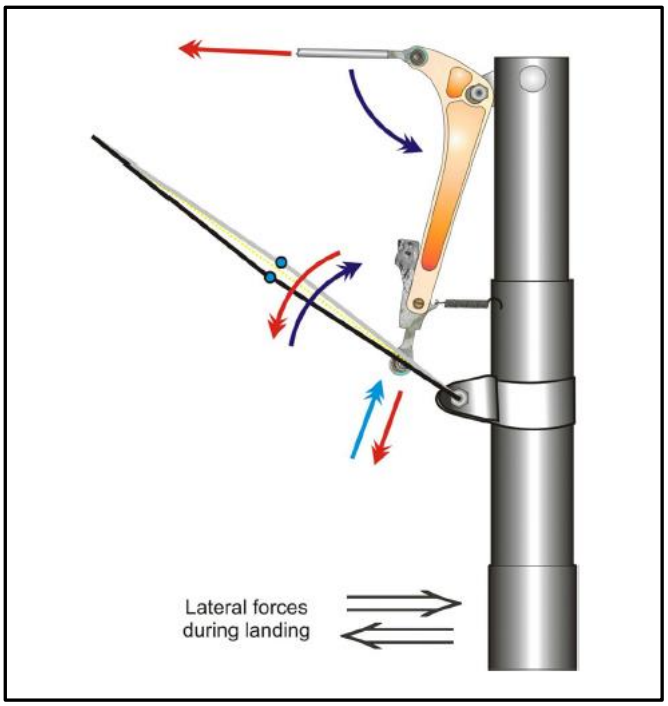

Illustration 2: Showing forces on the mechanism.

The mechanism must be properly adjusted or calibrated if it is to maintain a suitable geometry in all its configurations and 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. 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 bell-crank pivot bolt for signs of shear failure (SID 32-10-03).

1.17. Organisational and Management Information

1.17.1. The aircraft was operated privately as a hire-and-fly under the provisions of Part 91 of the CAR 2011 as amended.

1.17.2. The operator was issued a Certificate of Registration (C of R) by the Regulator on 30 July 2019.

1.17.3. The AMO that conducted maintenance on the aircraft had a valid AMO certificate that was issued by the Regulator on 6 May 2022 with an expiry date of 31 March 2023.

1.18. Additional Information

1.18.1. Similar Occurrences

The information below is an extract from Report IN-017/2006 Addenda Bulletin 3/2008

In the Civil Aviation Accident and Incident Investigation Commission (CIAIAC) database, there has been several cases relating to previous accidents relating to this one, involving breaks in the main landing gear extending-retracting mechanism on Cessna aircraft sharing the same landing gear design as the ZS-III.

- *A-71/2002: Cessna 402-B, dated 25 September 2002, right main gear: shear fracture of a section of the bell crank pivot bolt; fracture of one of the lugs on the front trunnion bolt supporting the pivot bolt; fracture of the bell-crank lower arm adjusting screw; and fracture of the push-pull tube where it joins the bell crank. No material defects were found. It was determined that the breaks were caused by an improperly adjusted extending-retracting and locking mechanism for the main landing gear leg.*

- *A-41/2004: Cessna 402B, dated 03 July 2004, left main gear: shear fracture of a section of the bell crank pivot bolt; fracture of one of the lugs on the front trunnion bolt, lateral bending failure of the lower bell-crank 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 402B, dated 03 July 2006, right main gear: shear fracture in two parts of the bell-crank pivot bolt; lateral bending failure of the lower bell-crank arm. No material deficiencies were found.*

Several cases were also found in the National Transport Safety Board (NTSB) database matching the events described in this accident.

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

- *LAX92LA138: Cessna 340A, dated 11 March 1992, left hand main gear: the bell-crank pivot bolt and the adjusting 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 bell-crank pivot bolt.*

- *LAX04LA149: Cessna 340A, dated 05 July 2006, right hand main gear: shear fracture in two places of the bell-crank. No material defects were found. The probable cause was an improper flare by the pilot which impacted high side loadings on the right main gear, leading to the overload failure of the bell-crank and the collapse of the landing gear.*

One occurrence was found in the United Kingdom's Air Accidents Investigation Branch (AAIB) database whose description and failure mode analysis are similar to those described herein:

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

The reports note a complicated procedure nature of 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.

As in those cases listed in above, the accidents involved different operators and even different aircraft share the same gear design, this is an indication that adjustment 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-centre adjustment must not be undertaken as an independent operation, but it must be taken 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 description for adjusting and rigging the main landing gear retraction-extension system and its spreading and practical application amongst the operators and maintenance centres of Cessna aircraft affected.

1.18.2 The Transport Canada also released a Cessna 300 and 400 series main landing gear malfunction - Service Difficulty Advisory: AV 2010-03 on 18 March 2010

On 3 June 2002, the Cessna Aircraft Company issued SID Number 32-30-05 titled "Main/Nose Gear Retraction Systems Teardown and Inspection". The primary purpose of the Cessna corrective action SID is to thoroughly inspect the MLG and adjacent structure in order to prevent gear extension and retraction malfunctions.

The SID also refers to Multi-engine Service Bulletin (SB) MEB88-5, Revision 2, which advises owners/operators to carry out initial and repeat inspections of the MLG trunnion lugs. Failure of the MLG trunnion lugs can result in substantial damage to the aeroplane and possible injury to occupants and/or ground personnel.

In addition, the Federal Aviation Administration (FAA) has recently issued Special Airworthiness Information Bulletin (SAIB) CE-09-16 advising operators of Cessna twin-engine aircraft to inspect for fatigue cracks on the MLG torque tubes. Please refer to Cessna SID 32-10-01 or 32-10-02 entitled "MLG Torque Tube Assembly" to determine affected models. Failure of a torque tube can cause damage to the main gear bell crank assembly resulting in MLG indication and retraction/extension problems. The SAIB also emphasizes that proper rigging of the landing gear is critical for safe operation. For further information please refer to the Cessna SB MEB09-2 entitled "MLG Torque Tube Life Limit".

Additionally, Transport Canada Civil Aviation (TCCA) has reviewed a previous (Spanish) foreign accident report on a Cessna 402B in which the L/H main landing gear collapsed while taxiing for take-off roll. The post-accident investigation revealed that the bell crank pivot bolt (NAS 464P4-26) had failed first in this sequence of events. Yet another Cessna 421B (Spanish) accident event reported landing gear collapse during landing. Significant damage occurred following skidding off the runway. The sheared bell crank pivot bolt, once again, appeared to be the initial component in the sequence of failures. Spanish authorities are aware of a number of other main landing gear pivot bolt failures and concluded that improper rigging of the landing gear can result in overload failure of the pivot bolt and consequent overload failure of the bell crank assembly. The complicated nature of the rigging procedures required for the main landing gear needs to be completed from start to finish. Even small adjustments can introduce a pre-load that exceeds the design criteria of the landing gear resulting in main gear collapse. To verify the integrity of the bell crank pivot bolt, compliance with Cessna SID 32-10-03 is strongly advised.

Aircrew should be aware that any problems with slow gear retractions/extensions and/or gear unsafe indications, coupled with a decay of climb/cruise speed, may be a warning of an impending MLG failure.

TCCA strongly advises owners, operators and other responsible agencies to comply with Cessna SID Numbers 32-30-05, 32-10-01, 32-10-02, 32-10-03, SB MEB88-5 and recently issued MEB09-2.

TCCA also advises Cessna 300/400 owners, operators and other responsible agencies that close monitoring of the various landing gear mechanisms and warning systems is needed. In particular, we strongly emphasize strict adherence to the manufacturers' maintenance instructions whenever rigging the landing gear system.

Malfunctions, defects and failures occurring on aeronautical products should be reported to Transport Canada, Continuing Airworthiness in accordance with CAR 521 mandatory Service Difficulty Reporting requirements.

A review of the maintenance records of the accident aircraft revealed that not all SID mentioned above were adhered to during maintenance. Only SID 32-10-03, SID32-10-05, SID 32-20-00, SID 32-30-00 and SID 32-30-07 were noted in the aircraft maintenance records. No further records on any of the SID mentioned above were indicated during the latest maintenance as they are applicable to airframe hours starting at 4000 hours. The aircraft was still at 2874.2 airframe hours at the time of the accident.

The report 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 absence of pre-existing metallurgical anomalies or defects which may contribute to or produced the failure.*

The maintenance of these aircraft components was in accordance with the manufacturer's instructions, and the Supplementary Inspection Documents (SIDs) 32-10-03 and 32-30-05 involving the landing gear had been implemented. At the date of the incident, sufficient time remained before the inspections required therein had to be repeated.

An uncommanded retraction of left-side landing gear leg took place during the aircraft's third landing run on the day.

The landing and 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 the truss assembly forward clevis ears which allow for non-continuity of the locking mechanism around the bell-crank axis of rotation.

The bends and breaks found allowed for the initial cause of the fault to be identified as the overload and the subsequent shear failure of the push-pull tube.

The overload in the locking mechanism was due either to a pre-load produced during the adjustments 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 bell-crank.

1.19. Useful or Effective Investigation Techniques

1.19.1. None.

2. ANALYSIS

2.1. General

From the available evidence, the following analysis was made with respect to this accident. This shall not be read as apportioning blame or liability to any organisation or individual.

2.2. Analysis

2.2.1. The pilot had a CPL Aeroplane which was initially issued on 29 June 2015. His licence renewal was issued by the Regulator on 24 November 2022 with an expiry date of 31 December 2023. The pilot also had a Class 1 medical certificate that was issued on 2 June 2022 with an expiry date of 30 June 2023. The aircraft type was endorsed on his licence. The pilot accumulated a total of 1600 flying hours of which 22.9 hours were on the aircraft type. The pilot also had a Grade 2 instructor rating and a Class 2 rating for instrument and test pilot.

2.2.2. The aircraft was issued a C of A by the Regulator on 9 November 2022 with an expiry date of 8 November 2023. The C of A was issued after the MPI was conducted by the approved AMO. The AMO issued the CRS on 3 August 2022 at 2823.3 airframe hours with an expiry date of 3 August 2023 or at 2923.3 airframe hours, whichever comes first. The aircraft had a total of 2874.2 airframe hours at the time of the accident.

2.2.3. The AMO that conducted maintenance on the aircraft had a valid AMO certificate that was issued by the Regulator on 6 May 2022 with an expiry date of 31 March 2023.

2.2.4. The aircraft was operated privately as a hire-and-fly under the provisions of Part 91 of the CAR 2011 as amended. The operator was issued a C of R by the Regulator on 30 July 2019.

2.2.5. The aircraft had sufficient fuel on-board at the time of landing. Good weather prevailed at the time of the flight. Both the weather and fuel cannot be attributed to the cause of this accident.

2.2.6. The failure occurred during a landing roll at low speed. The left main landing gear collapsed, and this caused damage to the push-pull tube and the bottom adjusting screw eye-end attachment. This further caused the multi propeller to strike the runway surface which led to damage of the propeller blade tips. Research showed similar occurrences on different Cessna aircraft models with the same landing gear type. It was also discovered that the failure on both the push-pull tube and the bottom eye-end were instantaneous due to excessive force as a result of an uncommanded left landing gear retraction.

Therefore, it was concluded that the uncommanded retraction of the left main landing gear collapse was due to an overload failure of the locking mechanism as a result of either the pre-load produced during the adjustment process or an oscillatory motion that resulted from an incorrect adjustment (looseness) and, due to the mechanism's geometry, this amplified the stress on the bell-crank.

2.2.7 The unlocking of the gear from the down position was due to the overload failure of the adjusting screw eye-end, which prevented the locking mechanism from rotating in the bell-crank axis.

2.2.8 This failure has already been identified by the manufacturer as evidenced by Supplemental Inspection Documents (SIDs) 32-10-03 and 32-30-05 and 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 bell-crank pivot bolt for signs of shear failure (SID 32-10-03).* Although the above SIDs were adhered to, the aircraft experienced an uncommand left main landing gear retraction during the landing roll. *TCCA 'strongly advised owners, operators and other responsible agencies to comply with Cessna SIDs Numbers 32-30-05, 32-10-01, 32-10-02, 32-10-03, SB MEB88-5 and the recently issued MEB09-2'.* At the time of the accident, the aircraft had been flown for 50.9 airframe hours after the MPI.

According to the manufacturer, making small adjustments to parts of the rigging can result in gear collapse.

3. CONCLUSION

3.1. General

From the available evidence, the following findings, causes and contributing factors were made with respect to this accident. These shall not be read as apportioning blame or liability to any organisation or individual.

To serve the objective of this investigation, the following sections are included in the conclusion heading:

- **Findings —** are statements of all significant conditions, events, or circumstances in this accident. The findings are significant steps in this accident sequence, but they are not always causal or indicate deficiencies.
- **Causes —** are actions, omissions, events, conditions, or a combination thereof, which led to this accident.
- **Contributing factors —** are actions, omissions, events, conditions or a combination thereof, which, if eliminated, avoided or absent, would have reduced the probability of the accident occurring, or would have mitigated the severity of the consequences of the accident. The identification of contributing factors does not imply the assignment of fault or the determination of administrative, civil, or criminal liability.

3.2. Findings

3.2.1. The pilot had a CPL Aeroplane which was initially issued on 29 June 2015. His licence renewal was issued by the Regulator on 24 November 2022 with an expiry date of 31 December 2023.

3.2.2. The pilot had a Class 1 medical certificate that was issued on 2 June 2022 with an expiry date of 30 June 2023. The aircraft type was endorsed on his licence. The pilot accumulated a total of 1600 flying hours of which 22.9 hours were on the aircraft type. The pilot also had a Grade 2 instructor rating and a Class 2 rating for instrument and test pilot.

3.2.3. The aircraft was issued a C of A by the Regulator on 9 November 2022 with an expiry date of 8 November 2023. The C of A was issued after the MPI was conducted by the AMO.

3.2.4. The AMO issued the CRS on 3 August 2022 at 2823.3 airframe hours with an expiry date of 3 August 2023 or at 2923.3 airframe hours, whichever comes first. The aircraft had a total of 2874.2 airframe hours at the time of the accident.

3.2.5. The AMO that conducted maintenance on the aircraft had a valid AMO certificate that was issued by the Regulator on 6 May 2022 with an expiry date of 31 March 2023.

3.2.6. The aircraft was operated privately as a hire-and-fly under the provisions of Part 91 of the CAR 2011 as amended. The operator was issued a C of R by the Regulator on 30 July 2019.

3.2.7. The uncommanded retraction of the left main landing gear was due to an overload in the locking mechanism which was caused by either a pre-load produced during the adjustment process, or to an oscillatory motion that led to an incorrect adjustment and looseness which, due to the mechanism’s geometry, amplified the stresses on the bell-crank.

3.2.8. The possibility of failure was already identified by the manufacturer as evidenced by Supplemental Inspection Documents (SIDs) 32-10-03 and 32-30-05 mentioned in Section 1.5 regarding inspection for excessive slack and wear in the landing gear retraction system (SID 32-10-05), and the inspection of the bell-crank pivot bolt for signs of shear failure (SID 32-10-03).

3.3. Probable Cause/s

3.3.1. The left main landing gear collapse was due to an overload failure of the locking mechanism as a result of either the pre-load produced during the adjustment process or an oscillatory motion that resulted from an incorrect adjustment (looseness) and, due to the mechanism's geometry, amplified the stress on the bell-crank.

3.4. Contributory Factor/s

3.4.1. The incorrect rigging during maintenance.

4. SAFETY RECOMMENDATIONS

4.1. General

The safety recommendations listed in this report are proposed according to paragraph 6.8 of Annex 13 to the Convention on International Civil Aviation and are based on the conclusions listed in heading 3 of this report. The AIID expects that all safety issues identified by the investigation are addressed by the receiving States and organisations.

4.2. Safety Recommendation/s

4.2.1. None.

5. APPENDICES

5.1. None.

This report is issued by:
Accident and Incident Investigations Division
South African Civil Aviation Authority
Republic of South Africa