Air Accident Investigation Unit Ireland

FORMAL REPORT

ACCIDENT

Cessna 750, Citation X+, N752TX

Cork Airport

22 July 2018

An Roinn Iompair
Turasóireachta agus Spóirt
Department of Transport,
Tourism and Sport

Foreword

This safety investigation is exclusively of a technical nature and the Final Report reflects the determination of the AAIU regarding the circumstances of this occurrence and its probable causes.

In accordance with the provisions of Annex 13[1] to the Convention on International Civil Aviation, Regulation (EU) No 996/2010[2] and Statutory Instrument No. 460 of 2009[3], safety investigations are in no case concerned with apportioning blame or liability. They are independent of, separate from and without prejudice to any judicial or administrative proceedings to apportion blame or liability. The sole objective of this safety investigation and Final Report is the prevention of accidents and incidents.

Accordingly, it is inappropriate that AAIU Reports should be used to assign fault or blame or determine liability, since neither the safety investigation nor the reporting process has been undertaken for that purpose.

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[1] **Annex 13**: International Civil Aviation Organization (ICAO), Annex 13, Aircraft Accident and Incident Investigation.
[2] **Regulation (EU) No 996/2010** of the European Parliament and of the Council of 20 October 2010 on the investigation and prevention of accidents and incidents in civil aviation.
[3] **Statutory Instrument (SI) No. 460 of 2009**: Air Navigation (Notification and Investigation of Accidents, Serious Incidents and Incidents) Regulations 2009.

AAIU Report No: 2019 - 009
State File No: IRL00918044
Report Format: Formal Report
Published: 23 September 2019

In accordance with Annex 13 to the Convention on International Civil Aviation, Regulation (EU) No 996/2010 and the provisions of SI No. 460 of 2009, the Chief Inspector of Air Accidents on 22 July 2018, appointed Kate Fitzgerald as the Investigator-in-Charge to carry out an Investigation into this Accident and prepare a Report.

Aircraft Type and Registration:	Cessna 750, Citation X+, N752TX	
No. and Type of Engines:	2 X Rolls-Royce AE3007C2	
Aircraft Serial Number:	750-0511	
Year of Manufacture:	2014	
Date and Time (UTC)[4]:	22 July 2018 @ 14.08 hrs	
Location:	Cork Airport (EICK)	
Type of Operation:	General Aviation	
Persons on Board:	Crew - 2	Passengers - 6
Injuries:	Crew - Nil	Passengers - Nil
Nature of Damage:	Substantial	
Commander's Licence:	Airline Transport Pilot Licence (ATPL), issued by the Federal Aviation Administration (FAA)	
Commander's Age:	56 years	
Commander's Flying Experience:	13,500 hours, of which 1,700 were on type	
Notification Source:	Cork Airport Duty Manager	
Information Source:	AAIU Report Form submitted by Pilot, AAIU Field Investigation	

[4] **UTC**: Co-ordinated Universal Time. All timings in this report are quoted in UTC; Local time was UTC +1 hour on the date of the accident.

SYNOPSIS

During departure from Cork Airport (EICK), the Cessna 750 Citation X+ with two flight crew members and six passengers on board, taxied from Stand 16, lined up on Runway (RWY) 16 and began the take-off roll. The Pilot-In-Command (PIC) aborted the take-off at a groundspeed of 67 knots (kts) due to a significant vibration from the nose wheel. The aircraft stopped on the runway and the passengers and crew disembarked, uninjured. The aircraft sustained substantial damage. There was no fire.

NOTIFICATION

The AAIU was notified by the Duty Manager at EICK. Two Inspectors of Air Accidents travelled to EICK and commenced an Investigation.

1. FACTUAL INFORMATION

1.1 History of the Occurrence

On 18 July 2018, following a flight from Luton Airport (EGGW), the aircraft landed at EICK and parked on Stand 16. After the passengers had disembarked, the two Pilots carried out post-flight checks and secured the aircraft. The aircraft remained on Stand 16 until the 22 July 2018 when the Pilots returned to prepare the aircraft for a flight to Gander, Newfoundland (CYQX).

Prior to departure for CYQX, the Flight Crew carried out pre-flight checks of the exterior of the aircraft and cockpit setup, dividing the tasks between the two crew members. When the six passengers arrived, they boarded promptly and final preparations for departure were completed. The aircraft taxied the short distance from Stand 16 to RWY 16 using '*taxiway Alpha*.' While taxiing, the PIC experienced some difficulties in turning the nose wheel. He discussed his concerns with the Second-In-Command (SIC) who confirmed that the relevant pre-flight inspection of the nose gear had been completed. The aircraft turned onto the runway and began the take-off roll. At a groundspeed of 67 kts the PIC aborted the take-off due to a significant vibration of the nose wheel. The maximum recorded ground speed was 74 kts, after which the aircraft decelerated and came to rest on RWY 16, where it was attended by Cork Airport Fire Services (AFS). Once the AFS had inspected the aircraft, the passengers disembarked through the main cabin door onto RWY 16.

1.2 Field Investigation

On arrival at EICK the Inspectors of Air Accidents inspected the aircraft and RWY 16, and made initial enquiries from witnesses and the Pilots. The Pilots were interviewed again by telephone at a later date.

1.3 Injuries to Persons

No injuries were reported to the Investigation.

1.4 Damage to Aircraft

The nose gear leg and nose structure of the aircraft suffered significant damage (**Photo No. 1**). During the accident sequence, the lower part of the nose gear leg turned through approximately 90 degrees, both tyres burst and disintegrated, leading to significant wear on the hub of the forward wheel (**Photo No. 2**). There was no fire.

The nose gear bay doors experienced bending damage and the aircraft's nose structure suffered a significant tear and distortion (**Photo No. 3**). The actuator used to extend and retract the nose landing gear also sustained bending damage.

Photo No. 1: Final Resting Position of Accident Aircraft on RWY 16 at EICK

Photo No. 2: Damage to Nose Gear Leg and Nose Structure

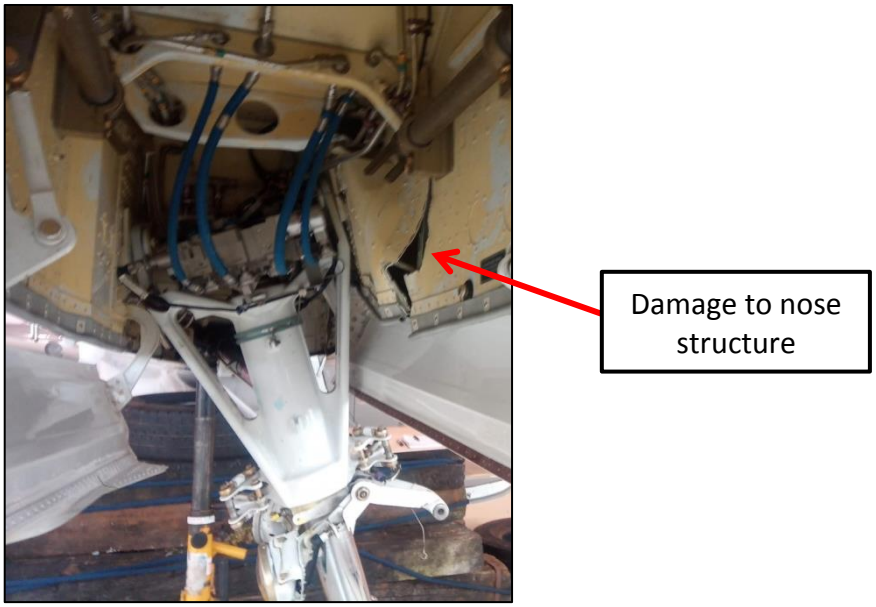

Photo No. 3: Damage to Aircraft Nose Structure

Several components were recovered along the runway. Amongst these was the nose gear leg Torque Link Release Pin, which is used to connect the upper and lower torque links on the nose gear leg (**Figure No. 1**). A pin which forms part of the internal retention mechanism of the Torque Link Release Pin was found in a separate location on RWY 16. Both are shown in **Photo No. 4**. There was no evidence of pre-existing mechanical damage. The safety pin that would normally be attached by a lanyard to the upper torque link was not recovered. However, the lanyard was found, still intact, and attached to the upper torque link.

Photo No. 4: Torque Link Release Pin with Damaged Lanyard (Left) and Internal Retention Pin (Right)

1.4.1 Nose Gear Leg Strip and Inspection

Following the occurrence, the nose gear leg was returned to the aircraft Manufacturer for strip-down and inspection. A report documenting the damage to the nose gear leg was produced. The damage described in the report included:

- The lugs attaching the nose gear leg power steering unit to the nose gear leg trunnion were snapped.
- One of the mountings for one of the power steering unit cable pulleys was snapped and the cable pulley had separated from the housing.
- The gear in the power steering unit could not be rotated by hand.
- The upper torque link had superficial paint damage and chip damage to the eyelet. The eyelet damage included a chip on the outer rim and two radiused indentations on the inner rim which were 180 degrees apart.
- Bending of upper torque link bolt.
- The lower torque link had superficial paint chipping, a gouge and rounding of edges.
- One of the bushes (which are a press fit) located in the eyelet of the lower torque link had migrated, and could not be moved by hand.
- The migrated bushing had a gouge on its rim.
- The lower barrel of the leg showed superficial paint chipping and damage to its lower end.
- The trunnion right mount lug had been bent inboard.
- The actuator rod end lug was bent.
- The housing of the actuator switch connection was damaged.

1.5 Other Damage

RWY 16 at EICK sustained minor scraping and indentation damage.

1.6 Personnel Information

1.6.1 General

The aircraft crew consisted of two pilots; both were qualified as aircraft commanders.

1.6.2 Aircraft Commander

Age:	56 years
Licence:	ATPL issued by the FAA
Last Periodic Check:	28 June 2018
Instrument Rating:	28 June 2018
Medical Certificate:	16 February 2018

Flying Experience:

Total all types:	13,500 hours
Total on type:	3,300 hours
Total on type P1:	1,785 hours
Last 90 days:	53 hours
Last 28 days:	6.3 hours
Last 24 hours:	0.9 hours (occurrence)

1.6.3 Second-In-Command

Age:	51 years
Licence:	ATPL issued by the FAA
Last Periodic Check:	1 February 2018
Instrument Rating:	1 February 2018
Medical Certificate:	17 April 2018

Flying Experience:

Total all types:	9,000 hours
Total on type:	543 hours
Total on type P1:	126 hours
Last 90 days:	75 hours
Last 28 days:	25 hours
Last 24 hours:	0.9 hours (occurrence)

1.7 Aircraft Information

1.7.1 General

The aircraft was a Cessna 750 Citation X+ powered by two Rolls-Royce AE3007C2 turbofan engines. The aircraft was manufactured in 2014 and operated on a Certificate of Airworthiness issued by the FAA.

1.7.2 Nose Wheel Steering

For the occurrence aircraft type, directional control on the ground is primarily provided by a nose wheel steering arrangement. A hydraulic power steering unit is connected to the upper nose gear leg, which transmits steering commands from the cockpit to the leg. The upper leg is connected to the lower leg and nose wheel using a torque link (**Section 1.7.3**).

The Flight Crew can check the pressure of the hydraulic system in the nose wheel steering system to verify that it is within acceptable margins, but there is no other cockpit indication that would identify a problem with the nose gear leg.

1.7.3 Nose Wheel Torque Link

The torque link is disconnected for towing by removing a safety pin, and Torque Link Release Pin. The safety pin and Torque Link Release Pin are attached to the upper torque link by thin, stranded-wire lanyards. When the torque links are disconnected, the lower leg and nose wheel are free to turn, allowing the aircraft to be steered (within certain Manufacturer limits) when it is under tow. **Figure No. 1** shows the torque link in a disconnected configuration.

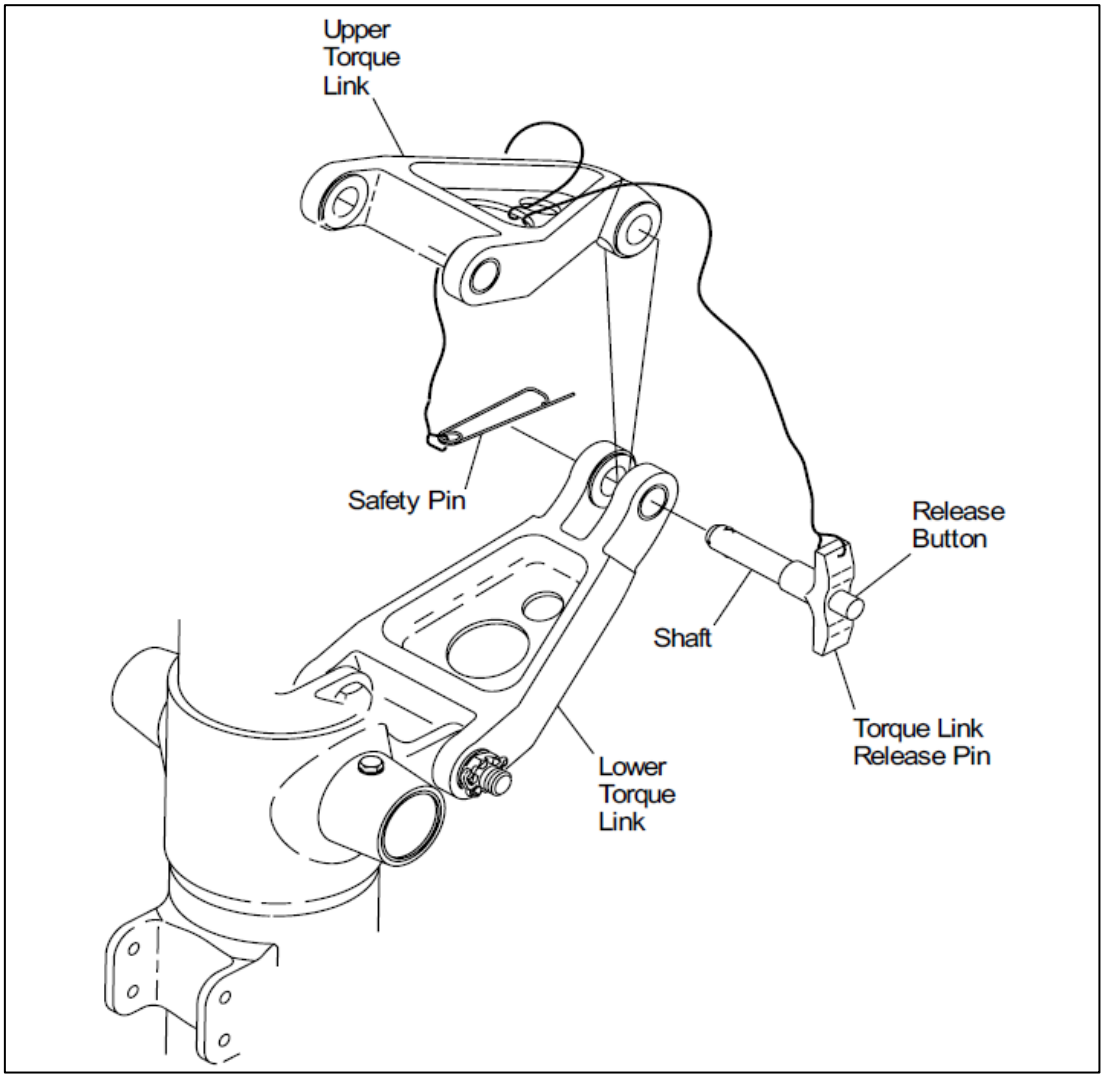

Figure No. 1: Disconnected Nose Gear Leg Torque Link (Courtesy of Textron Aviation)

1.7.4 Maintenance History

The aircraft was owned, operated and maintained by a corporate flight department.

1.7.5 Aircraft Manuals

A *'Normal Procedures'* checklist was carried in the cockpit of the aircraft. The installation of the Torque Link Release Pin is covered during the *'Wheels / Tires / Strut'* inspection which is part of the *'Exterior Inspection'* in **Figure No. 2** (red box added by the Investigation for emphasis).

SECTION III - OPERATING PROCEDURES
NORMAL PROCEDURES

MODEL 750

Exterior Inspection

In cold weather (below -15°C (+5°F) and/or icing conditions), refer to Section III, Operating Information, Extreme Cold Weather Operations and Section VII, Advisory Information, Ground Deice/Anti-ice Operations. Give particular attention to engine inlets, fan blades, wheel wells, wing trailing edge (forward of flaps) and behind slats for ice/slush from previous landing.

During inspection, make a general check for security, condition, and cleanliness of the airplane and components. Check particularly for damage, fuel, oil and hydraulic leakage, security of access panels and doors, and removal of keys from locks.

WARNING

Pitot tubes and AOA probes may still be hot.

Left Forward Fuselage

1. Cabin Door and Seals . . . . . **Condition**
2. Fairing Vent . . . . . **Clear**
3. RAT Probe . . . . . **Clear**
4. AOA Probe . . . . . **Rotates Freely**
5. Static Ports and Surrounding Fuselage Skin . . . . . **Clear,** Clean, No Damage
6. Pitot Tube . . . . . **Clear**

Left Nose Compartment

1. Emergency Gear and Brake Pressures . . . . . **Check Per Placard**
2. Nosewheel Steering Accumulator Precharge Pressure (bleed to precharge) . . . . . **Check Per Placard**
3. Static Drain . . . . . **Closed**
4. Oxygen Bottle . . . . . **Valve Wired Open**
5. Air Data and Rain Removal Hoses . . . . . **Connected**
6. Nose Compartment Door . . . . . **Secure/Locked**

Nose Gear/Radome

1. Taxi Lights . . . . . **Condition**
2. Wheels/Tires/Strut . . . . . **Condition/Torque Link Pin Installed**
   a. Nose strut extension should be between 3.25 and 7.0 inches.
3. Wheel Well . . . . . **Condition**
4. Gear Doors . . . . . **Condition/Secure/ Linkage Overcenter**
   a. The linkage is overcenter when the upper portion of the door pushrod is pointing slightly outboard and the flat lower end of the linkage assembly is against the stop bolt on each side of the nose wheel well.
5. Radome . . . . . **Condition/Secure**

(Continued Next Page)

Figure No. 2: Extract from Normal Procedures Checklist

The *'Normal Procedures'* Checklist did not specify what configuration, connected or disconnected, the torque link should have been left in post-flight, when the aircraft was parked.

1.7.6 Aircraft Maintenance Manual (AMM)

The Manufacturer provided the AMM to the Investigation. The section of the AMM which deals with aircraft towing, stated, *'When you remove the torque link release pin, the torque links are spring-loaded to extend horizontally from the nose gear strut.'*

When inspecting the aircraft, the Investigation noted that the lower torque link was not spring-loaded, and had fallen, under gravity, between the wheels. The Manufacturer informed the Investigation that by design, the lower torque link was not spring-loaded and that the AMM description was incorrect. The Manufacturer advised the Investigation that it now intends to amend the AMM.

1.7.7 Previous Events

The Investigation carried out a search of the NASA ASRS database[5] for occurrences relating to the nose gear leg Torque Link Release Pin of the Cessna Citation. The search returned five relevant occurrences. These were on Cessna Citation C560XL aircraft, which has a similar torque link arrangement to the Cessna 750 Citation X+. Details of these events are given in **Appendix A**. A common theme in these five events was an incorrectly installed Torque Link Release Pin or disconnected Torque Link which was not detected during pre-flight checks.

The Manufacturer informed the Investigation that as a result of these events they issued optional Service Bulletin SB560XL-32-38-R01. This allows operators to replace the quick disconnect pin with a bolt and is effective to certain ranges of serial numbers within the 560 XLS and 560 XLS+ fleet. The Manufacturer also informed the Investigation that 560 Excel aircraft within a certain serial number range were assembled with a bolt connection on the nose gear torque link. Operators could modify the bolt to a quick release arrangement by applying optional Service Bulletin SB560XL-32-20.

The Manufacturer noted that a difference between the 560XL range of aircraft and the occurrence aircraft (750 range) is that the 560XL have a mechanical steering system consisting of cables, bungees and gears. This allows these aircraft to be towed with the torque link connected. The 750 range of aircraft has a hydraulically driven steering system. This means that in order to prevent damage to the hydraulic steering unit, the torque link must be disconnected for towing.

1.8 Meteorological Information

The PIC informed the Investigation that there was no significant weather at the time of the occurrence. There was a 10 kts wind from the southeast and visibility was in excess of 10 miles.

[5] **NASA ASRS Database:** The US National Aeronautics and Space Administration, Aviation Safety Reporting System Database. This is a repository of de-identified aviation occurrences, managed by NASA.

1.9 Aerodrome Information

EICK has two runways, both of which have a grooved asphalt surface. The occurrence runway, 16/34 is 2,133 m in length. The handling agent at EICK informed the Investigation that, at the time of the occurrence, it did not have a tow bar capable of towing a Cessna 750 Citation X+.

1.10 Flight Recorders

1.10.1 Cockpit Voice Recorder (CVR)

The aircraft was fitted with an L3 FA2100 CVR which contained three channels (Commander's microphone, Co-Pilot's microphone and Cockpit Area microphone). Each channel recorded two hours of audio.

The Investigation downloaded and analysed the audio which began during the previous flight from EGGW to EICK. In the section of the audio file which related to the flight from EGGW to EICK, the Pilot's conversation does not indicate any abnormalities during the landing in EICK or the taxi to Stand 16. The CVR stopped recording when the aircraft was depowered and restarted when the Pilots returned on 22 July to make preparations for their outbound flight.

On 22 July 2018, the CVR recorded the short taxi from the parking stand to RWY 16 in EICK. During the taxi, the Pilots can be heard carrying out a series of pre-flight checks. These included a check of the nose wheel steering which the PIC verbally confirmed was working. When the aircraft was holding short of RWY 16, the PIC carried out a take-off briefing.

Three minutes before the end of the recording ATC gave the aircraft clearance to taxi onto RWY 16, line up and wait. During the taxi on to the runway, the PIC commented several times that the nose wheel steering was '*really slow*'. The PIC asked the SIC, *'was the nose gear in… the pin in?'* The SIC confirmed *'the pin in?...yeah..yeah..I checked it.*' A few seconds later, the PIC commented again that the steering was *'really really slow'* and that *'something's not right'.* The SIC re-iterated that the '*pin was in*', to which the PIC responded *'it was?*' and the SIC confirmed '*yeah*'.

The CVR recorded ATC giving the aircraft take-off clearance and the engines were heard spooling up. A few seconds later the CVR recorded a series of harsh mechanical sounds which continued as the take-off was aborted and the aircraft was brought to a stop.

1.10.2 Flight Data Recorder

The aircraft was fitted with an L3 FA2100 Flight Data Recorder (FDR) capable of recording 25 hours of flight data. The FDR did not record any parameters related to nose wheel steering as there are no sensors on the nose gear leg of this aircraft. However, the FDR confirmed that during the taxi, the PIC used the aircraft rudder to assist with steering. The data also shows that the aircraft taxied slowly (<9 kts maximum ground speed), that the take-off was aborted at 67 kts groundspeed and the maximum groundspeed reached by the aircraft was 74 kts. Other significant aircraft systems (such as engines, rudder and braking systems) appear to have been operating normally at the time of the occurrence.

1.11 Other Recorded Data

1.11.1 Closed Circuit Television (CCTV)

The Investigation obtained the CCTV footage from EICK of the aircraft arriving in Cork on the 18 July and parking on stand. The CCTV shows that after landing, the Pilot turned the aircraft through 180^{o} in order to taxi to the allocated parking stand. On arrival at stand, the Pilot turned the aircraft through 270^{o} in order to park as directed by the ground marshaller.

At the start of the CCTV file for the 22 July the flight crew were already at the aircraft making preparations for the flight and had started their pre-flight checks. The CCTV footage showed the SIC carry out a walk-around of the aircraft. During this walk-around one of the Pilots appeared to carry out a visual check of the nose area of the aircraft but did not bend down to examine the nose gear leg or Torque Link Release Pin closely. The Investigation acknowledges that other checks of the nose gear leg may have been made prior to the start of the CCTV footage.

When the six passengers arrived at the aircraft they boarded promptly and the aircraft was prepared for take-off. Two ground handling staff members were in attendance to assist the passengers and marshal the aircraft. The CCTV footage shows the aircraft taxiing a short distance from the stand to the holding point for RWY 16. The aircraft then enters the runway, turns and lines up for take-off. The total distance from the parking stand to RWY 16 was approximately 400 m and the taxi took less than two minutes. With regards to steering, the footage shows that the aircraft initially had to bear right, followed by a slight left turn, it then bore right again, followed by a long, slow, left turn on to the runway.

1.11.2 Photographic Information

The Investigation was provided with CCTV footage and a photograph of the aircraft as it taxied out to depart EGGW on 18 July 2018. In the photograph it is clear that the torque links were connected.

The Investigation was also supplied with a number of photographs taken on the morning of the accident at Cork Airport. In these photographs the torque links are disconnected (**Photo No. 5**).

Photo No. 5: Occurrence Aircraft Parked at EICK taken on 22 July 2018 at 09:22 hrs

1.12 Witness Interviews

1.12.1 Pilot-In-Command

Following the occurrence, the PIC provided the Investigation with a detailed account of the previous flight from EGGW to EICK on 18 July 2018 and the occurrence on the 22 July 2018. The PIC informed the Investigation that the previous flight from EGGW had been normal. Upon landing in EICK they taxied to Stand 16, turned the aircraft around and parked. When the passengers had disembarked the two Pilots carried out the tasks required to secure the aircraft. These included putting on engine and pitot covers and removing rubbish from the passenger cabin.

The PIC stated that when parking, the Operator's SOP requires pilots to secure the aircraft cabin but leave the brakes off, so that the aircraft can be towed in the pilot's absence if required. The SOP does not give any specific instructions with regards to the status of the nose gear Torque Link Release Pin (i.e. installed or removed), but the PIC's own preference was not to touch the pin unless it was absolutely necessary. He noted that he occasionally put the Torque Link Release Pin back into the top half of the torque link after disconnecting it so that the pin would not blow around in the wind and cause damage to the nose gear leg. The PIC did not recall either removing the pin prior to leaving the aircraft, or discussing towing the aircraft with the FBO[6]. After the occurrence the PIC asked the FBO if the aircraft had been moved and the FBO stated that it had not.

The PIC informed the Investigation that on the 22 July 2018, both Pilots returned to the aircraft approximately two hours before their scheduled flight time to prepare the aircraft and that they were under no particular time pressure. The PIC stated that normal procedure is for the SIC to carry out external checks of the aircraft. However, on this occasion, the PIC was conscious that both Pilots needed to work together on the flight plan, and he offered to carry out the checks on the aircraft nose, which he said would include a visual check of the nose gear Torque Link Release Pin. The PIC stated that a physical check of the pin is only required if the pilot observes any anomalies during the visual check.

The PIC noted that the taxi from Stand 16 to RWY 16 was very short. During the taxi the PIC was required to carry out some checks which included a sweep of the nose wheel steering and a deployment of the thrust reversers. The PIC informed the Investigation that both of these checks were normal. However, as the aircraft turned onto the runway the PIC noticed that the nose steering felt sluggish and recalled that he had discussed this with the SIC. The aircraft weighed 36,400 lbs (as it was carrying a full fuel load) and was travelling at a low speed during the short taxi. In the initial part of the take-off roll, the steering seemed normal but at about 70 kts the nose wheel began to shimmy significantly. The PIC immediately aborted the take-off. The PIC informed the Investigation that in this aircraft type there are no cockpit annunciations that would alert a pilot to a nose wheel problem, unless the problem related to a failure of the hydraulic system.

The PIC informed the Investigation that the type rating carried out by the crew for the aircraft required pilots to complete a virtual walk-around inspection of the aircraft. The Operator augmented this training by giving new pilots walk-around experience accompanied by a more senior pilot.

1.12.2 Second-In-Command

The SIC informed the Investigation that he had been the PIC for the two previous flights into and out of Luton, UK. He noted that there were no anomalies on either flight and that the landing into EICK followed by a long taxi to stand was normal. The SIC stated that the FBO in EICK had made it clear to him that the aircraft would not be moved and the SIC stated that the Flight Crew had briefed to leave the torque links connected.

[6] **FBO:** Fixed Base Operator; An organisation that has been granted permission by an airport to offer services (such as fuel, hangarage, maintenance, parking, aircraft rental etc.) at that airport.

On the day of the occurrence the SIC carried out the pre-flight checks to the rear of the exterior of the aircraft and the passenger cabin, as the PIC had offered to carry out the pre-flight checks for the nose and cockpit areas. The SIC noted that the flight crews tend to operate as a team and that this informal division of tasks was not unusual. The SIC also recalled looking at the nose gear as he walked past it and noticing that '*the pin was in*'. However, the SIC also noticed that there was shadowing around the nose wheel, that the aircraft was very heavy, which would have compressed the nose gear and he believed that this may have affected his view.

The SIC informed the Investigation that his normal practice was to leave the torque links connected and this would be included in his briefings. On the occasions when he disconnected the pin, he would leave the pin hanging by its lanyard, but the SIC noted that some pilots disconnect the pin and put it back into the top half of the torque links. When disconnected, the bottom half of the torque links normally remains visible but the SIC noted that sometimes the bottom half of the link can fall to a resting position between the wheels which obscures it from sight.

The SIC informed the Investigation that this aircraft had a '*T-handle*' which, when pulled, allows the aircraft fuel tanks to take 200-300 lbs extra fuel. Prior to the taxi, the two Pilots had discussed fuel and the PIC decided to pull the '*T-handle*' and uplift the extra fuel. In addition, the SIC noted that the taxi out to RWY 16 was deliberately very slow to allow time for the taxi checks to be completed and also that the grooved, asphalt surface at EICK was high friction. The SIC informed the Investigation that, in his experience, the steering of this aircraft could feel heavy in such circumstances. Therefore, he did not find it particularly unusual when the PIC observed that the steering felt slow.

The SIC stated that the aircraft made several turns during the taxi and line up on RWY 16 and that the last turn was a slow and tight 90^{o} turn. Following the turn the aircraft tracked correctly on the runway centreline. The SIC did not believe that this turn would have been possible if there was something wrong with the nose wheel steering.

1.13 Useful or Effective Investigation Techniques

1.13.1 Computerised Tomography Scan

The Torque Link Release Pin was found after the occurrence on RWY 16. The lanyard which attached the pin to the nose gear leg appears to have failed during the accident sequence. An inspection of the pin mechanism was not immediately possible due to the fact that it was largely a sealed unit. The pin was subsequently taken by an Inspector of Air Accidents to a specialist CT[7] scanning facility where a full scan was carried out. The resulting images showed no evidence of a pre-existing failure that would have prevented the correct functioning of the pin. **Figure No. 3** shows an example CT cross-sectional scan through the pin.

[7]**CT Scan**: An X-ray image made using a form of tomography in which a computer controls the motion of the X-ray source and detectors, processes the data, and produces the image.

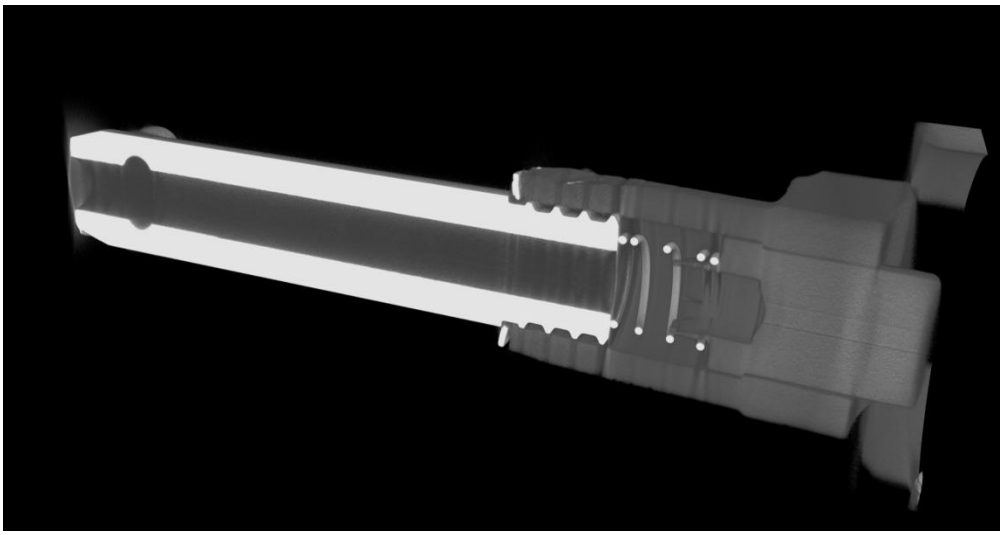

Figure No. 3: Example Cross-Section through the Quick Release Pin

1.13.2 Human Factors

Psychologists describe the concept of '*Perceptual set*' and its relevance to the process of perception. McLeod[8] uses the definition, ***'Perceptual set** is a tendency to perceive or notice some aspects of the available sensory data and ignore others.'*

In such cases, the perceiver has certain expectations and focuses attention on particular aspects of the sensory data. The perceiver already knows how to classify and understand this particular sensory data, and importantly, what inferences they can draw from it.

In addition, psychological experiments have demonstrated that the way a visual stimulus is verbally identified, affects how it is subsequently perceived. *Beaty*[9] describes an experiment in which participants were divided in to two groups and shown a series of shapes. Each group was then given a verbal identification for the shapes and asked to reproduce them. Two examples from the results are shown in **Figure No. 4** below:

First Group's Reproduction	Verbal Identification	Figure Shown	Verbal Identification	Second Group's Reproduction
	Eye Glasses		Dumb bells	
	Crescent Moon		Letter C	

Figure No. 4: Example Results from Psychological Experiment

[8] McLeod, S. A. (2010). *Perceptual set*. Retrieved on 6 August 2019 from https://www.simplypsychology.org/perceptual-set.html

[9] *Beaty, D* (e-book, 2011), '*The Naked Pilot. Human Factors in Aircraft Accidents*.' Airlife England

Beaty went on to say:

Once a perceptual experience has been named, then, we appear to be satisfied with that interpretation. We think we have identified the object adequately, even if in fact there are many aspects of it which we have missed.'

2. ANALYSIS

2.1 Mechanical Aspects

The aircraft sustained a substantial amount of damage to the nose gear leg and nose structure during this occurrence. Inspection of the aircraft and the parts that were recovered from RWY 16 at EICK indicated that the damage was likely a result of commencing the take-off roll with the nose gear leg torque links disconnected. **Photo No. 5**, which was taken shortly before the occurrence, showed the aircraft parked with the torque links disconnected and the Torque Link Release Pin stored in the upper half of the torque links. Neither Pilot recalled disconnecting or reconnecting the torque links. The Investigation examined the upper and lower torque links that were intended to connect the nose wheel and the nose steering column. The torque links were disconnected, but otherwise appeared to be functional and had sustained only minor damage.

The Torque Link Release Pin was found on RWY 16 having become separated from the aircraft due to the failure of the attaching lanyard. The retention pin which is part of the Torque Link Release Pin was found in a different location on the runway. The Investigation consider it probable that the retention pin became detached due to the forces experienced by the Torque Link Release Pin as it separated from the aircraft and bounced on the runway. A CT scan of the Torque Link Release Pin was carried out and did not reveal any pre-existing defects that would have led to a failure of the Torque Link Release Pin mechanism.

CCTV footage shows that in order to transit from Stand 16 to RWY 16, the aircraft had to bear right, followed by a slight left turn, it then bore right again, followed by a slow, long left turn on to the runway. The Investigation was initially of the opinion that it would not be possible to steer the aircraft with disconnected torque links. However, previous incidents on similar aircraft (**Appendix A**) demonstrate that similar manoeuvres were possible with a disconnected torque link. In these previous incidents pilots were able to steer the aircraft for a short period of time, (sometimes a taxi, take-off and landing), before the problem manifested itself as a nose wheel vibration, often described as a '*shimmy*' by pilots. The Investigation believes that these examples indicate that it is possible to have a level of '*stiction*'[10] between the upper and lower nose gear leg, allowing the leg to operate normally for a short period with disconnected torque links.

In this occurrence, the distance between the aircraft parking stand and the runway was very short (approximately 400 m). CCTV footage and FDR data showed the aircraft was travelling very slowly, with the entire taxi taking less than two minutes. '*Stiction*' combined with the fact that the aircraft was heavy, and was moving and turning slowly, permitted a degree of steering. In addition, FDR data shows that the PIC used the rudder during the taxi to assist with steering.

[10] **Stiction:** A type of friction which tends to prevent stationary objects from being set in motion.

It is unlikely that a serviceable, correctly installed pin would have failed and come loose during this short taxi. Therefore, it is the opinion of the Investigation that the disconnection of the nose wheel and nose steering column was not caused by a mechanical failure of the torque links or Torque Link Release Pin, and it is more likely that the torque links were not connected prior to the aircraft taxiing to RWY 16.

2.2 Operational Aspects

The occurrence aircraft was operated as a corporate aircraft. The nature of an operation of this type is that the aircraft does not follow a fixed operational schedule. Instead, it responds to the requirements of the corporation, flying to a multitude of airfields with different levels of ground support. The two members of the flight crew are a mobile team, carrying out some of the tasks that in a commercial airline would be carried out by cabin crew or line engineers.

The normal checklist contained within the AFM for this aircraft requires the pilot to check that the Torque Link Release Pin is installed prior to flight. However, this check is combined with a condition check of the *'wheels/tires/strut'*. It is the opinion of the Investigation that combining several checks together in this manner could subconsciously reduce the significance of each individual item. Therefore, it would be preferable for each significant task to be an individual line item in the checklist. The AFM does not contain any post-flight requirements for the torque links i.e. the pilot may choose to leave the torque links in a connected or a disconnected state.

The Flight Crew in this occurrence were both rated Captains which meant that there was a potential for a shallow authority gradient[11] across the flight crew. However, CVR evidence indicated that this was not the case during either the occurrence flight, or the previous flight. In both flights, the roles of PIC and SIC in the cockpit were clear.

The delineation of roles does not appear to have been as well-defined for the tasks that occurred between flights, i.e. post and pre-flight checks. In this case the pre-flight inspection of the exterior of the aircraft, a task which in most commercial airline operations would be carried out by the SIC, was shared between both pilots. The result of this was that both Pilots believed that they had checked the Torque Link Release Pin, and the fact that they were of equal rank, may have made them more likely to accept their colleague's assessment that '*the pin was in'*, despite contradictory tactile feedback from the aircraft steering.

2.3 Human Factors

The concept of *'Perceptual Set'* presented in **Section 1.13.2** describes the human tendency to perceive some aspects of available data and ignore others. This applies particularly when the perceiver has certain expectations of what they are going to see and focuses attention on these aspects. In this occurrence the Pilots expected to see an installed Torque Link Release Pin.

[11] **Authority Gradient**: Authority Gradient refers to the established, and/or perceived, command and decision-making power hierarchy in a Team, Crew or Group situation, and also how balanced the distribution of this power is experienced within the Team, Crew or Group. Concentration of power in one person leads to a steep gradient, while more democratic and inclusive involvement of others results in a shallow gradient.

Photographs of the aircraft, taken a few hours before the occurrence, showed that the Torque Link Release Pin was installed in the upper torque link, but that the torque links were not connected.

Beaty[9] also describes the fact that attaching a verbal identifier to a visual stimulus can affect the way that humans perceive that stimulus and cause aspects of the stimulus to be missed. Following the occurrence, the SIC described how pilots are trained to check the Torque Link Release Pin. He stated that pilots are trained to check that the '*pin is in'*. When the PIC initially identified an issue with the nose wheel steering he asks the SIC, *'was the nose gear in… the pin in?'* The SIC repeated this phraseology, reassuring the PIC that, *'The pin in? Yeah […]'*. The SIC restated this later on in the conversation, '*The pin was in'*.

In post-occurrence interviews, both Pilots referred to the fact that the aircraft was heavy and was carrying the maximum load of fuel. In addition, the distance to the runway was short and the aircraft was moving slowly partly to facilitate pre-flight checks. The SIC also explained that in his experience the steering could feel '*heavy*' when the aircraft was fully laden. This, combined with the fact that both pilots were satisfied that the '*pin was in*' may explain why the Pilots were not unduly alarmed when the steering felt heavier than normal.

The fact that both the '*Normal Checklist*' and pilot training directs pilots to check for the presence of the Torque Link Release Pin focusses attention on the Torque Link Release Pin only. Therefore, it would not be surprising if pilots unconsciously began to look only at the pin, and missed the other critical aspect of this stimulus which is the status of the upper and lower torque link assembly.

By design, it was intended that when disconnected, the Torque Link Release Pin would be suspended from the upper torque link by its lanyard. This would provide a visual indication that the link was disconnected. However in this case, photographs taken of the aircraft on the day of the occurrence, show that the Torque Link Release Pin was re-installed in the upper torque link after the torque links had been disconnected. The occurrence Pilots informed the Investigation that this was relatively common practice amongst pilots to prevent damage to the nose gear leg which could be caused by the Torque Link Release Pin blowing in the wind. The '*Normal Checklist*' for the aircraft does not specifically prohibit storing the Torque Link Release Pin in this manner, and it is understandable that pilots who are trained to be cognisant of potential damage to the aircraft, might take basic measures to prevent damage from occurring.

In addition, an error in the AMM may have led the Pilots to expect another visual cue to indicate that the torque links were disconnected. The AMM states that, *'When you remove the torque link release pin, the torque links are spring-loaded to extend horizontally from the nose gear strut.'* The Manufacturer informed the Investigation that this was an error. The lower torque link was not spring loaded and could fall down between the wheels when disconnected. Therefore, the visual cue that the Pilots may have expected would not have existed.

2.4 Summary

In this occurrence the Investigation was unable to determine the precise sequence of events that led to the nose gear leg torque links becoming disconnected. However, as photographs taken just prior to the occurrence show that the torque link assembly was disconnected, and a CT scan of the Torque Link Release Pin following the occurrence indicated that there was no evidence of a mechanical failure, the Investigation considers it likely that the torque link assembly was disconnected whilst the aircraft was parked and not reconnected prior to the aircraft commencing its taxi on to RWY 16.

The design of the torque link mechanism does not give pilots any obvious visual warning when the torque link is disconnected. The Torque Link Release Pin itself, when suspended by its lanyard from the upper torque link could provide such a warning, but this is problematic as the pin can be installed in the upper torque link only, thus removing the visual warning. This is exacerbated because the aircraft checklists, operating procedures and pilot training focus the pilot's attention on the Torque Link Release Pin only.

In this occurrence, the Pilots were able to maintain control of the aircraft and bring it to rest safely with no injuries to passengers or crew. However, the aircraft sustained substantial damage at a relatively low speed, and under different circumstances the outcome could have been much more serious. For these reasons the Investigation issues the following Safety Recommendation to the aircraft Manufacturer:

Safety Recommendation

Textron Aviation should undertake a review of the torque link design and associated operational procedures on the Cessna Citation 750 series with a view to implementing measures which will increase the probability that disconnected torque links will be detected prior to taxiing the aircraft (**IRLD2019-002**).

3. CONCLUSIONS

3.1 Findings

1. Both Pilots were suitably qualified to conduct the flight.
2. The aircraft was airworthy with no pre-existing mechanical issues that could have caused this occurrence.
3. Photographic evidence shows the torque links were disconnected on the morning of the occurrence with the Torque Link Release Pin installed in the upper torque link.
4. There was no evidence of a pre-existing mechanical failure of the upper or lower torque link or the Torque Link Release Pin.
5. The *'Normal Checklist'* does not require pilots to leave the Torque Link Release Pin in any particular configuration when the aircraft is parked at an aerodrome.

6. The pre-flight inspection of the torque links are part of the wheels/tires/strut inspection in the aircraft operations manual and requires pilots to check that *'Torque Link Pin installed.'*

7. Both Pilots reported that the pre-flight inspections were carried out.

8. The Torque Link Release Pin was attached to the upper torque link by a wire lanyard and the pin could be blown against the nose gear leg when not installed.

9. The taxi distance from Stand 16 to RWY 16 at EICK was very short (approximately 400 m) and the aircraft taxied slowly.

10. One of the checks required by the operations manual during taxi was a nose wheel steering check. The CVR recorded the PIC carrying out this check and noting that it was normal.

11. The CVR recorded the PIC expressing his concerns about the nose wheel steering as the aircraft lined up on the runway.

12. The two Pilots discussed the PIC's concerns but concluded that the Torque Link Release Pin was installed.

13. When discussing the nose wheel torque link assembly, both Pilots focussed on the location of the Torque Link Release Pin (i.e. '*the pin was in'*) and did not discuss the status of the assembly (disconnected or connected).

14. The SIC reported that during training the pilots are taught to check that the *'pin is in'*.

15. The Pilot aborted the take-off at 67 kts due to a significant shimmy on the nose wheel.

16. Following the occurrence, the nose wheel was found disconnected from the steering column.

17. The occurrence caused significant damage to the nose gear leg and nose structure of the aircraft.

18. The NASA ASRS database includes five previous, similar incidents which occurred on Cessna Citation C560XL aircraft, which has a similar nose wheel steering pin mechanism.

3.2 Probable Cause

1. Pre-flight checks of the aircraft exterior did not identify that the torque link assembly was disconnected.

3.3 Contributory Causes

1. Absence of a visual warning on the torque link assembly to draw a pilot's attention to an incorrectly installed Torque Link Release Pin.
2. Absence of a design feature on the torque link assembly to prevent incorrect installation of the Torque Link Release Pin.
3. The pre-flight check of the torque link assembly is merged with the checks for '*wheels*' and '*tires*'.
4. Shallow cockpit gradient.
5. The phraseology used in the aircraft '*Normal Checklist'*, pilot training and by pilots to describe the installation of the Torque Link Release Pin.
6. The AMM erroneously stated that the lower torque link was spring-loaded and would extend horizontally from the nose strut when disconnected.

4. SAFETY RECOMMENDATIONS

No.	It is Recommended that:	Recommendation Ref.
1.	Textron Aviation should undertake a review of the torque link design and associated operational procedures on the Cessna Citation 750 series with a view to implementing measures which will increase the probability that disconnected torque links will be detected prior to taxiing the aircraft.	IRLD2019-002

View Safety Recommendations for Report 2019-009

- END -

Appendix A

Previous Occurrences

Reference Number	Date	Aircraft Model	Description
697016	May 2006	Citation Excel (C560XL)	Nose wheel steering pin disconnected on take-off roll around 70 kts. Aborted take-off. Towed back to FBO after fire dept ensured no smoke, fire, or other heat damage. 2 pax on board were reassigned another aircraft. Steering pin installation on this aircraft is held in place with a small safety pin. The pin should not be removed during towing unless the tug has to exceed 90 degrees l/r of centre, which should be very rare, if ever. Current production has replaced this safety pin the bolts to avoid events like the one described. The steering assembly looked ok on pre-flight, but I can't rule out pilot error in failing to catch a safety pin that was not quite latched properly after we were towed the previous evening (by line workers at FBO). Nothing was broken or sheared off on post incident maintenance inspection. Perhaps a lesson on extra careful pre-flight attention to murphy's law-prone components. As these planes go in for maintenance, the pin is being replaced by bolts (permanent).
699383	June 2006	Citation V/Ultra/Encore (C560)	Aircraft had service bulletin for disconnect pin for nose gear. Pin was removed by FBO for aircraft tow. Was not properly replaced by ground crew and not rechecked by flight crew. Taxi, take-off and landing normal. Landing normal until rollout below 60 kts then aircraft nose wheel shimmy developed. Cleared runway, reconnected, inspected nose gear and taxied to FBO. Tire changed, inspected by maintenance personnel, no further damage.
702984	July 2006	Citation Excel (C560XL)	After landing in aspen, co, I turned off the runway. Almost immediately we experienced violent nose wheel shimmy at approx 5 kts. I stopped the aircraft. The captain went outside to examine the nose wheel and found the steering mechanism disconnected and the pin removed. The pin had the safety wire still installed. He reconnected the steering and installed the pin and we were towed to parking. A maintenance inspection determined there was no damage and the aircraft was cleared for flight.
1354574	May 2016	Citation Excel (C560XL)	**Narrative 1:** Aircraft parked with many others on a "closed" taxiway, i.e., remote. Thunderstorm was in progress with moderate to heavy precipitation. Lighting was "dim to nil". As per SOP, [First Officer (FO)] first to arrive at aircraft to perform pre-flight inside and out. I arrived +45 later concurrent with the arrival of our 8 passengers. I performed normal outside check and boarded aircraft. We were given clearance to taxi from parked position to "Spot Yellow" making normal turns for about 1 mile. Given taxi clearance to RW 17L and soon felt nose wheel shimmy. Requested and given clearance to stop and pulled aside (no other aircraft near us). I shut-down left engine and went outside while [FO] remained at his station. I found the nose wheel steering pin not properly installed. I re-connected the assembly and considered the condition "corrected" and with the concurrence of my flying partner decided the flight could continue as planned. Received ATC clearance to continue taxiing and completed the flight. Post flight inspection found the steering pin installed but the safety pin was NOT locked, i. e., Safety Pin not perfectly functional. I completed a Maintenance Log Book Entry and notified maintenance as per SOP. [Suggest] Standardization of Excel fleet to re-fit all nose wheel steering with "permanent" steering pins. **Narrative 2:** The aircraft was parked at a remote ramp without any lighting. It was raining and lightning strongly. I did the

Reference Number	Date	Aircraft Model	Description
			required walk around and pre-flight duties. After the captain had taxied approximately 1.5 miles, making a 90 degrees right turn out of the parking position, and 3 left turns, the nose gear began to shake. We thought, we might have a flat tire, or ran over something in the dark, while taxiing. The Captain brought the aircraft to a stop. We notified ATC that the aircraft was disabled on the taxiway. The Captain set the brakes, shut down the engine, and proceeded to inspect the nose gear, while I remained in the cockpit. The Captain found that the scissors on the nose gear had become loose. He attached the scissors back together, started the left engine, notified ATC, and we continued to taxi.
1416161	January 2017	Citation Excel (C560XL)	Upon arrival our passengers were escorted by the PIC and transported to the aircraft by FBO staff. SIC had completed the pre-flight activities and passengers were boarded. PIC did a final walk around. Neither crew member noted any discrepancies prior to the flight. [Airport] was the site of [a sporting event] and the airport was heavily congested with aircraft, so all taxiing was done at a slow pace. We were cleared to taxi from the [FBO] ramp onto Taxiway "Z" and to hold short of Taxiway "Z1", and to expect Runway "ZZ". With the marshal's signal be began taxiing straight ahead for about 20 feet and made a left turn heading for Taxiway "Z". As we approached "Z" the pilot flying said the steering felt a little sluggish and asked if I had checked the torque link pin. I said I had done my final walk around, but didn't notice anything abnormal; however wasn't 100% sure that the torque link pin itself was installed. I decided to make a few turns left and right to insure we had the torque link connected. In addition to the initial 90 degree turn as we began to taxi, the pilot flying made turns of approximately 45 degrees left and right. Both crew members were satisfied that the torque pin "must" have been installed or else we would not have been able to steer the aircraft with nose wheel steering. […] As we accelerated to approximately 20-30 knots, we felt excessive nose wheel shimmy and aborted the take-off. Pilot not flying notified Tower of the aborted take-off and we exited the runway onto Taxiway "Z", holding short of Taxiway "Z3". Contacting Ground, we were given taxi instructions straight ahead on "Z" and then onto the [FBO] ramp. The pilot flying taxied very slowly turning right onto [FBO's] ramp and left to parking as instructed by the lineman marshal. We secured the aircraft and the PIC exited to check the torque link. Finding the pin installed, PIC went back and informed the SIC that the pin was installed, and that he was going inside the FBO to call Flight Control and Maintenance Control. When the PIC exited again, the marshal informed him that he noticed the "steering scissors" were disconnected, so he connected them and installed the pin. PIC notified Flight Control and Maintenance Control and described the events. Maintenance requested pictures of the torque link from two different angles with the pin installed. A maintenance technician was dispatched to inspect the nose gear assembly and the PIC made a discrepancy report in the Aircraft Maintenance Log (AML). The maintenance technician performed a thorough inspection and completed the maintenance log noting no discrepancies found. Maintenance Control and Flight Control released the flight to continue.

In accordance with Annex 13 to the Convention on International Civil Aviation, Regulation (EU) No. 996/2010, and Statutory Instrument No. 460 of 2009, Air Navigation (Notification and Investigation of Accidents, Serious Incidents and Incidents) Regulation, 2009, the sole purpose of this investigation is to prevent aviation accidents and serious incidents. It is not the purpose of any such investigation and the associated investigation report to apportion blame or liability.

A safety recommendation shall in no case create a presumption of blame or liability for an occurrence.

Produced by the Air Accident Investigation Unit

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