Aviation Investigation Final Report

Location:	Chicago, Illinois	**Incident Number:**	DCA15IA089
Date & Time:	March 14, 2015, 15:21 Local	**Registration:**	N157GJ
Aircraft:	BOMBARDIER INC CL 600 2C10	**Aircraft Damage:**	Minor
Defining Event:	Sys/Comp malf/fail (non-power)	**Injuries:**	41 None
Flight Conducted Under:	Part 121: Air carrier - Scheduled		

Analysis

The flight crew had flown the incident airplane on the day before the incident and heard a sound, which the captain described as a “bang,” when extending the landing gear on approach. The first officer inspected the nose gear after landing and indicated that it looked like the data plate had come loose on the strut. The captain sent photographs of the nose landing gear to company maintenance control and then entered “placard strap bent” in the airplane logbook. He did not write up the “bang” sound because of his conversation with maintenance control. Maintenance personnel repaired the damaged placard that night but did not do any additional inspections. If the captain had been more descriptive in his writeup, additional maintenance would likely have been completed that may have found the mechanical failure in nose gear system.

During the incident flight, the crew observed a GEAR DISAGREE caution message during their approach and conducted a go-around to troubleshoot the problem. The first officer, as pilot monitoring, began performing the GEAR DISAGREE checklist, however, he misstated several items in the checklist and did not perform the last item that directed him to perform another checklist. Although operational issues were identified during this investigation related to checklist usage and company procedures, they did not relate or contribute to the cause of the incident. The flight was subsequently cleared to land, and the airplane touched down without the nose gear extended, which resulted in minor damage to the forward fuselage.

Nose Landing Gear Failure

The opening and closing of the landing gear doors were accomplished through the driven link, lower link, and upper link assemblies, articulated by the drive link assembly attached to the drive arm assembly. Postincident examination of the nose landing gear revealed that two areas on the lower link assembly had damage from contacting the upper link assembly and the drive link assembly. The spherical bearing attached to the drive link assembly had fractured away

from the lower link assembly. The drive arm assembly that attached to the lower lock link assembly using two D head pin/nut combinations had only one pin/nut still attached; the bolt and washer were heavily distorted. The portion of the hole in the lower lock link assembly that facilitated one of the two bolts/nuts to fasten the drive arm assembly was found sheared from the lug. Examination of the primed mating surfaces of the drive arm assembly and lower lock link assembly revealed missing paint adjacent to the bolt holes, indicating back-and-forth movement between the two components.

Given that the end of the protruding threads on the sheared pin did not show any physical damage from the threads interacting with the nut, it is likely that one of the two nuts on the lower D head pins securing and providing anti-rotation between the drive arm assembly to the lower lock link assembly lost preload and backed off. With the nut missing from the D head pin, the drive arm assembly was allowed to have side-to-side rotational movement as well as a gap with the lower lock link assembly during the extension and retraction of the gear. Given the absence of the nut and the resulting gap between components, loads were transferred to the upper D head pin, which caused the aluminum lug to fail in tensile overload.

With the upper D head pin no longer attached, the entire load was transferred through the lower D head pin, and the subsequent loads applied resulted in fracture of the lower pin in shear. Because the drive arm was no longer tethered to the lock link, the drive arm was free to rotate, and, thus, the door links were able to go over center, farther than designed, allowing the drive rod to contact the lower link. When the nose landing gear was commanded to extend, the drive link could not pull the upper/lower link out of lock and, thus, as the nose landing gear continued to traverse, the rod end of the driven link contacted the lower link and subsequently failed in bending. As a result, the door linkage was no longer connected to the kinematics of the landing gear; the air loads on the forward doors held the upper and lower linkage in the over center condition, and the nose landing gear subsequently rested on the forward doors.

Thus, the nose landing gear failed to fully extend when the lower link, upper link, and driven link assemblies articulated over center, mechanically immobilizing those components and the attached door rods, preventing them from fully extending. The over centering of the linkage occurred due to the overtravel of the drive link assembly, which was the result of missing and damaged fastening hardware on the drive arm assembly.

After the incident, GoJet Airlines inspected its fleet of 47 CRJ 700 airplanes to ensure that the nose landing gear drive arm attaching hardware was intact. As a result of the detailed inspection, three airplanes were found with loose hardware, which was replaced in accordance with the applicable maintenance manual. In addition, Goodrich published a Service Bulletin that directed operators to remove the drive arm pin nuts, replace them with nuts with a new part number, and install them with Loctite at a higher torque value. Bombardier also published a Service Bulletin, which recommended operators accomplish the Goodrich Service Bulletin within 1,320 flight hours from the bulletin release date.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this incident to be:

The nose landing gear's failure to fully extend due to missing and damaged fastening hardware on the drive arm assembly.

Findings

Aircraft	Nose/tail gear attach section - Failure

Factual Information

History of Flight

Approach	Sys/Comp malf/fail (non-power) (Defining event)
Landing-landing roll	Sys/Comp malf/fail (non-power)

On March 14, 2015, about 1521 central daylight time, GoJet Airlines, dba United Express, flight 3645, a Bombardier CL-600-2C10, N157GJ, landed with the nose landing gear not extended on runway 32R at Chicago O'Hare International Airport (ORD), Chicago, Illinois. None of the 44 passengers and crew on board were injured, and the airplane sustained minor damage. The flight was operating under the provisions of Title 14 Code of Federal Regulations Part 121 as a regularly scheduled passenger flight from Gerald R. Ford International Airport (GRR), Grand Rapids, Michigan, to ORD.

On the previous day, the incident flight crew had flown the incident airplane to GRR and heard a sound when extending the landing gear on approach; all three landing gear extended normally. In a postincident interview, the captain described the sound as a "bang" that he thought was odd and that he had not heard before. The first officer indicated that, after landing, he inspected the nose gear, and it looked like the data plate had come loose on the strut. The captain stated that he sent photographs of the nose landing gear to company maintenance control personnel, who indicated that the problem appeared to be with the placard strap. The captain entered “placard strap bent” in the airplane logbook; he stated that he did not write up the “bang” sound but based his logbook entry on his conversation with maintenance control. Maintenance was performed on the airplane overnight to repair the damaged placard.

The next day, another crew flew the incident airplane on two legs, from GRR to Denver and back to GRR. The first officer of the other crew stated that they heard a "slight noise" when extending the gear for landing, which that captain described as a “little click,” and stated that this information was relayed to the incident captain.

For the incident flight, the captain was the pilot flying and the first officer was the pilot monitoring. The flight departed GRR about 1413, and during landing gear retraction, the crew heard a noise that the first officer later described as a "good clunk." They discussed the noise but continued the flight to ORD.

About 1438, during approach to runway 27L at ORD, the first officer selected the landing gear down, and the crew observed a GEAR DISAGREE caution message on the engine indicating and crew alerting system (EICAS). About 1439, the first officer cycled the landing gear handle up and back down, and they again observed a GEAR DISAGREE message on the EICAS along with a red nose gear position indicator. The crew conducted a go-around and received radar vectors from air traffic control (ATC) out of the airport traffic area to troubleshoot the

problem.

About 1442, the first officer started to perform the GEAR DISAGREE checklist contained in the Quick Reference Handbook (QRH). In following steps in the checklist, the first officer cycled the landing gear handle up and then down again. According to the cockpit voice recorder (CVR), at 1444:21, the first officer stated that a note in the checklist said "not to do it more than once." The GEAR DISAGREE message persisted, and, at 1445:14, the CVR recorded a click as the first officer pulled the landing gear manual release handle.

The landing gear manual release handle activation attempt was unsuccessful, and the first officer continued to read the checklist, stating the next step was to accomplish the Landing Gear Up/Unsafe Landing procedure. Instead, the first officer performed the LDG GEAR Lever Jammed in the UP Position checklist, which was located at the top of page 13-5. He completed that checklist and read the last step that again directed them to accomplish the Landing Gear Up/Unsafe Landing procedure, which was located at the bottom of page 13-5. At 1447:14, the first officer stated "...and that's what we're doing...," followed by "...and that's-that, we're done."

The flight crew discussed the fuel remaining and decided to conduct a low approach to have ATC tower personnel visually observe the landing gear position. At 1448:21, the crew declared an emergency with ATC, and shortly after, the captain briefed the cabin crew and passengers. The crew conducted the low approach, and, at 1459:13, an ORD ATC tower controller advised them that the nosewheel was "...definitely not down. or appears not down." After the low approach, the crew discussed landing and evacuation procedures, briefed the passengers, and then discussed evacuation procedures with the cabin crew.

At 1512:52, ATC cleared the flight for the instrument landing system runway 32R approach. The crew configured the airplane for landing with flaps 45, and, at 1517:30, the ORD ATC tower cleared the flight to land on runway 32R.

At 1519:06, the first officer announced "brace, brace, brace" over the public address (PA) system. At 1520:32, the main landing gear touched down on the runway, and, at 1520:50, the CVR recorded the sound of scraping as the forward end of the fuselage contacted the runway. After the airplane came to a stop on the runway, the flight crew advised the cabin crew "...do not evacuate" and announced over the PA, "...no evacuation."

The flight crew shut down the engines and electrical power, and the passengers and crew remained on the airplane until ground transportation was available to transport them to the gate. The passengers then exited through the main forward cabin doors.

DAMAGE TO AIRPLANE

Postincident examination of the airplane revealed minor damage to the nose landing gear doors, and a bolt and bracket on the drag brace were found broken. The nose gear strut was not damaged and remained inside the nose gear well, with no evidence that it had dragged on the ground.

Pilot Information

Certificate:	Airline transport	**Age:**	29,Male
Airplane Rating(s):	Single-engine land; Multi-engine land	**Seat Occupied:**	Left
Other Aircraft Rating(s):	None	**Restraint Used:**	5-point
Instrument Rating(s):	Airplane	**Second Pilot Present:**	Yes
Instructor Rating(s):	None	**Toxicology Performed:**	No
Medical Certification:	Class 1 Without waivers/limitations	**Last FAA Medical Exam:**	February 3, 2015
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	December 13, 2014
Flight Time:	5222 hours (Total, all aircraft), 3734 hours (Total, this make and model), 1146 hours (Pilot In Command, all aircraft), 160 hours (Last 90 days, all aircraft), 17 hours (Last 30 days, all aircraft), 7 hours (Last 24 hours, all aircraft)		

Co-pilot Information

Certificate:	Airline transport	**Age:**	51,Male
Airplane Rating(s):	Single-engine land; Multi-engine land	**Seat Occupied:**	Right
Other Aircraft Rating(s):	None	**Restraint Used:**	5-point
Instrument Rating(s):	Airplane	**Second Pilot Present:**	Yes
Instructor Rating(s):	Airplane multi-engine; Airplane single-engine	**Toxicology Performed:**	No
Medical Certification:	Class 1 Without waivers/limitations	**Last FAA Medical Exam:**	January 15, 2015
Occupational Pilot:	Yes	**Last Flight Review or Equivalent:**	October 21, 2014
Flight Time:	14106 hours (Total, all aircraft), 894 hours (Total, this make and model), 12265 hours (Pilot In Command, all aircraft), 191 hours (Last 90 days, all aircraft), 42 hours (Last 30 days, all aircraft), 7 hours (Last 24 hours, all aircraft)		

The captain was hired by GoJet Airlines in February 2011 as a first officer and was upgraded to captain in 2013. The captain reported 5,222 hours total time, including about 1,146 hours as pilot-in-command and 3,734 hours total time on the CL-65; 892 of which was as pilot-in-command. The captain had type ratings for BE-1900 and CL-65 airplanes. There were no records or reports of previous aviation incidents or accidents involving the captain.

The first officer was hired by GoJet Airlines in October 2013. He reported 14,106 hours total flight time and 894 hours second-in-command time in the CL-65He held type ratings for LR-Jet, DA-10, and CL-65 airplanes. There were no records or reports of previous aviation

incidents or accidents involving the first officer.

The captain and first officer had not flown together before this trip, and the incident occurred on the first leg of the second day of the trip.

Aircraft and Owner/Operator Information

Aircraft Make:	BOMBARDIER INC	**Registration:**	N157GJ
Model/Series:	CL 600 2C10 700C	**Aircraft Category:**	Airplane
Year of Manufacture:	2005	**Amateur Built:**	
Airworthiness Certificate:	Transport	**Serial Number:**	10230
Landing Gear Type:	Retractable - Tricycle	**Seats:**	
Date/Type of Last Inspection:	March 12, 2015 Continuous airworthiness	**Certified Max Gross Wt.:**	
Time Since Last Inspection:		**Engines:**	2 Turbo fan
Airframe Total Time:	26123 Hrs at time of accident	**Engine Manufacturer:**	General Electric
ELT:		**Engine Model/Series:**	CF34-8C5B1
Registered Owner:	AFS INVESTMENTS 73 LLC	**Rated Power:**	
Operator:	GOJET AIRLINES LLC	**Operating Certificate(s) Held:**	Flag carrier (121)
Operator Does Business As:		**Operator Designator Code:**	N6WA

The incident airplane's nose landing gear was a double wheel, forward retracting type with two spin down assemblies. The nose landing gear consisted of a twin wheel shock strut and a folding drag brace that incorporated a mechanical downlock/uplock.

In normal operation, the nose landing gear drag brace assembly folded and positioned the shock strut relative to the nose of the fuselage in both extend and retract positions. It consisted of an upper drag brace, lower drag brace, over center lock link assembly (jury strut), and two tension springs. The upper drag brace assembly connected the lower drag brace assembly and the jury strut assembly to the airframe attachment point. The lower drag brace assembly connected the upper drag brace and the jury strut assembly to a lug integral to the forward side of the outer cylinder.

The jury strut assembly, comprised of lower and upper lock link assemblies, connected the upper and lower drag brace assemblies to the airplane attachment point, over center springs, and the lock actuator. Dual acting springs assisted the lock link assembly arms and were designed to ensure over center and mechanical locking of the jury strut.

The nose landing gear doors were driven by the nose landing gear and were open when the nose landing gear was down and closed when the gear was up. The nose landing gear doors

opened and closed with landing gear motion through mechanical means. The forward door mechanism assembly was comprised of two door rods, a driven link assembly, upper and lower locks link assemblies, a drive link assembly, and a drive arm assembly. The door rods, each with rod ends and spherical bearings at each end, attached to lugs integral to their respective door assembly. Both door rods then connected to lugs integral to the driven link assembly, which had a clevis at the opposite end for pinning to a lug integral to gear bay structure.

The driven link assembly was acted upon by an upper link assembly, which connected to a lower link assembly. The lower link assembly was pinned to the upper drag brace and acted upon by the drive link assembly. The drive link assembly was pinned to the drive arm assembly, which was rigidly attached to the lower lock link of the jury strut.

When nose landing gear extension would begin, hydraulic pressure would be directed to the lock actuators, which would break the over center lock of the lock link assembly. The nose landing gear would be brought down and locked in the extended position by the retract actuator and two tension springs. The lock actuator and the tension springs completed a solid over center lock of the lock link assembly. To retract the nose landing gear, the hydraulic pressure would be directed to the lock actuator to break the downlock and to the retract actuator to raise the nose landing gear. The nose landing gear would retract into the wheel well and be locked into position by the two tension springs.

Maintenance

At the time of the accident, the GoJet Airlines CRJ 700 maintenance program was controlled by its Continuous Airworthiness Maintenance Program document, revision 41, dated December 19, 2014. The maintenance program consisted of line checks, work packages, and block checks, progressing from lighter to heavier maintenance requirements. The investigation revealed that all required maintenance had been performed. The nose landing gear and drag brace were due for overhaul in early 2016.

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual (VMC)	**Condition of Light:**	Day
Observation Facility, Elevation:	KORD,672 ft msl	**Distance from Accident Site:**	0 Nautical Miles
Observation Time:	14:51 Local	**Direction from Accident Site:**	0°
Lowest Cloud Condition:	Few / 5000 ft AGL	**Visibility**	10 miles
Lowest Ceiling:		**Visibility (RVR):**	
Wind Speed/Gusts:	16 knots / 21 knots	**Turbulence Type Forecast/Actual:**	/ Unknown
Wind Direction:	300°	**Turbulence Severity Forecast/Actual:**	/ Unknown
Altimeter Setting:	30.01 inches Hg	**Temperature/Dew Point:**	14°C / 2°C
Precipitation and Obscuration:			
Departure Point:	GRAND RAPIDS, MI (GRR)	**Type of Flight Plan Filed:**	IFR
Destination:	Chicago, IL (KORD)	**Type of Clearance:**	IFR
Departure Time:	15:00 Local	**Type of Airspace:**	Class B

Airport Information

Airport:	Chicago O'Hare KORD	**Runway Surface Type:**	Concrete
Airport Elevation:	672 ft msl	**Runway Surface Condition:**	Dry
Runway Used:	32R	**IFR Approach:**	Unknown
Runway Length/Width:	10005 ft / 150 ft	**VFR Approach/Landing:**	Full stop;Traffic pattern

Wreckage and Impact Information

Crew Injuries:	4 None	**Aircraft Damage:**	Minor
Passenger Injuries:	37 None	**Aircraft Fire:**	None
Ground Injuries:	N/A	**Aircraft Explosion:**	None
Total Injuries:	41 None	**Latitude, Longitude:**	41.986667,-87.897781

Postincident examination of the nose landing gear revealed that two areas on the lower link assembly displayed damage from contacting the upper link assembly and the drive link assembly. The spherical bearing attached to the drive link assembly was found to have fractured away from the lower link assembly. The drive arm assembly that attached to the

lower lock link assembly using two D pin/MS21042L4 nut combinations was recovered with only one pin/nut still attached; the bolt and washer were heavily distorted. The portion of the hole in the lower lock link assembly that facilitated one of the two bolts/nuts to fasten the drive arm assembly was found sheared from the lug. Examination of the primed mating surfaces of the drive arm assembly and lower lock link assembly revealed missing paint 180° from each other adjacent to the bolt holes, indicating back-and-forth movement between the two components.

Flight recorders

The airplane was equipped with a CVR and a flight data recorder (FDR). More information about the CVR and FDR can be found in the public docket for this accident.

Additional Information

Postincident Actions

On September 11, 2015, the nose landing gear manufacturer (Goodrich) published Service Bulletin 52200-32-88, which directed operators to remove the drive arm pin nuts, replace them with nuts with a new part number, and install them with Loctite at a higher torque value. The bulletin indicated that "[o]perators have reported loose drive arm pins PN [part number] 52621-1. Loose drive arm pin nuts could lead to damage of the drag brace jury strut attachment flange."

On October 2, 2015, the airplane manufacturer (Bombardier) published Service Bulletin 670BA-32-055, which provided operators with instructions for Goodrich Service Bulletin 52200-32-88. The bulletin indicated that "[i]t is possible for the drive arm of the NLG [nose landing gear] drag brace to be disconnected from the lower lock-link assembly, if one or both nuts for the attachment pins come off. This can cause the NLG to not extend." Bombardier recommended that operators accomplish the service bulletin within no more than 1,320 flight hours from the bulletin release date, unless otherwise directed by the operator.

In addition, GoJet Airlines initiated a campaign to inspect all CRJ 700 airplanes within its fleet to ensure that the nose landing gear drive arm attaching hardware was intact. The campaign included a detailed visual inspection to check for the presence of the two attaching pins, two flat washers, and two self-locking nuts. In addition, the inspection checked to ensure that threads were protruding from the self-locking nuts. Three of the 47 airplanes inspected were found with loose hardware, which was replaced in accordance with the applicable maintenance manual.

Administrative Information

Investigator In Charge (IIC):	Lovell, John
Additional Participating Persons:	David Gerlach; Federal Aviation Administration Erik Kientzy; GoJet Airlines Beverley Harvey; TSB of Canada Jimmy Avgoustis; Bombardier (Tech Adviser to TSB) Simon Lucas; UTAS (Tech Adviser to TSB) Craig Markert; Int'l Brotherhood of Teamsters (Pilot's Union)
Original Publish Date:	February 24, 2021
Last Revision Date:	
Investigation Class:	Class 3
Note:	The NTSB did not travel to the scene of this incident.
Investigation Docket:	https://data.ntsb.gov/Docket?ProjectID=90870