

National Transportation Safety Board

Office of Aviation Safety

Washington, DC 20594



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SYSTEMS

Group Chair's Factual Report

August 14, 2024

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A. ACCIDENT

Location: Charlotte, NC
Date: June 28, 2023
Time: 08:52 EDT
12:52 UTC
Airplane: Boeing 717-200, N955AT

B. SYSTEMS GROUP

Group Chair	Adam Huray National Transportation Safety Board Washington, DC
Group Member	Dan McCully Federal Aviation Administration Atlanta, GA
Group Member	Gena Schaut Delta Air Lines Inc. Atlanta, GA
Group Member	Nathan Butcher Airline Pilots Association Atlanta, GA
Group Member	Steven Haggerty Boeing Seal Beach, CA

C. SYSTEMS DESCRIPTION

The 717 has a tricycle-type landing gear arrangement with one nose landing gear assembly and two main landing gear assemblies (see Figure 1). The landing gear holds the airplane weight when the airplane is on the ground, and absorbs shock loads during towing, taxi, takeoff, and landing. The landing gear system includes extension and retraction functions to stow the gear when the airplane is not on the ground, and an alternate extension function in case the normal extension function fails.

Landing gear doors close behind the gear when the gear is in the up position. In the case of the nose landing gear, there are two forward and two aft doors. The two forward doors close with the gear fully extended or fully retracted. The aft doors

close when the gear is up and stay open when the gear is down. The doors make the shape of the lower nose when the gear retracts.

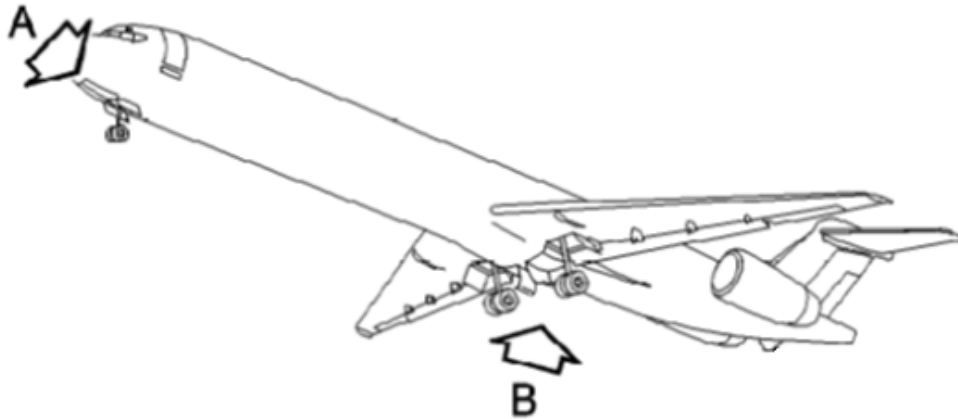


Figure 1. 717 landing gear. Arrow A points to the nose landing gear assembly and arrow B points to the two main landing gear assemblies. (Copyright Boeing. Used with permission.)

1.0 Nose Landing Gear Assembly

The nose landing gear housing attaches to the aircraft structure by the cross arm support. The nose landing gear housing also includes side braces that take vertical and lateral loads from the nose gear. The torque links allow the piston-axle to move in and out of the shock strut cylinder while preventing the piston-axle from turning in the cylinder. See Figure 2.

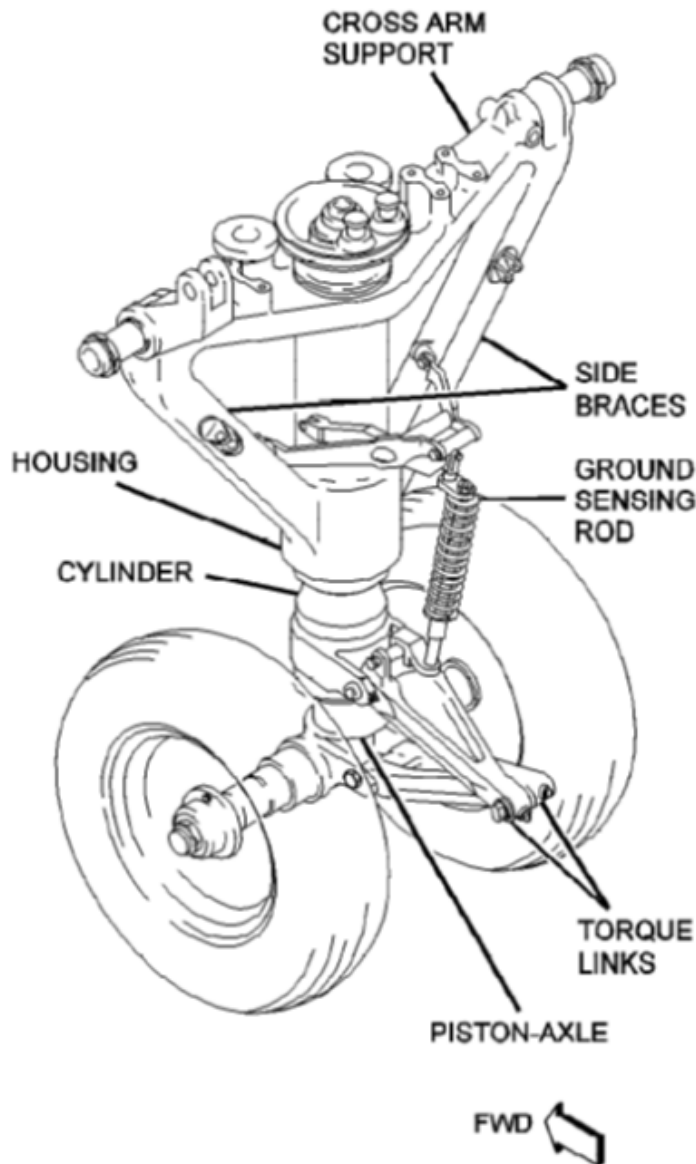


Figure 2. Nose landing gear assembly. (Copyright Boeing. Used with permission.)

2.0 Nose Landing Gear Braces and Actuation Components

Different braces and attachments attach the nose landing gear to the aircraft and hold necessary gear positions (see Figure 3). The upper and lower drag links connect together to take lateral loads from the nose gear. The lower drag link attaches to a fitting on the forward side of the strut housing. The upper drag link attaches to the torque tube. When the landing gear extends, the drag links hold the nose gear fully down and locked. When the landing gear retracts, the drag links fold up with the shock strut and hold the gear fully up and locked. Movement of the drag links turns the torque tube to open and close the forward gear doors.

The upper and lower lock links supply a connection between the drag links and the aft bulkhead structural member of the nosewheel well. The lower lock link connects to the drag links, and the upper lock link connects to the aft bulkhead in the nosewheel well. The lock links move to a mechanical over-center position with the gear fully up and fully down. This operation locks the drag links to hold the nose gear in the extended and retracted positions.

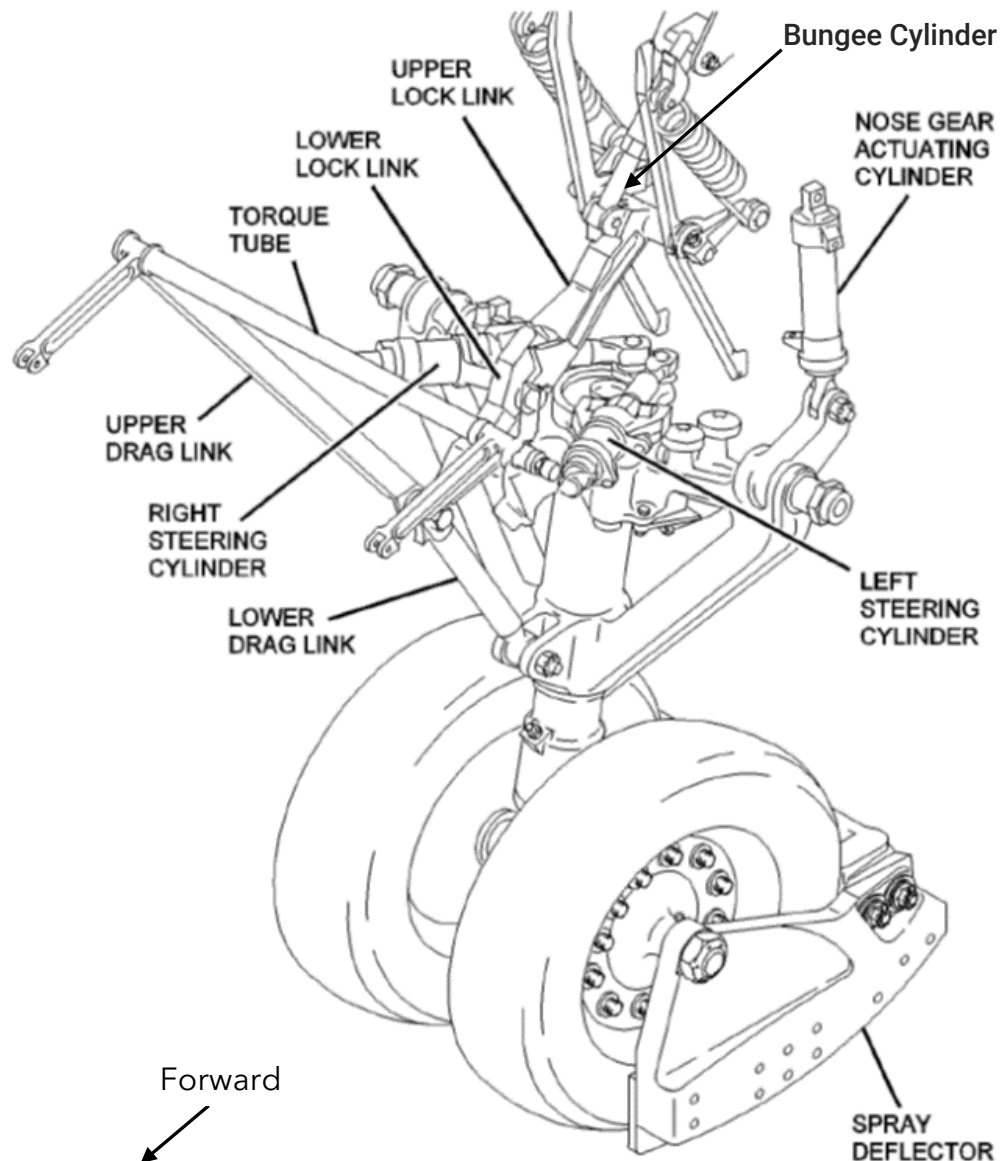


Figure 3. Nose landing gear with braces and actuation components attached. Note only the right upper drag link is shown (the left upper drag link is identical but connects to the left side of the lower drag link and the left side of the torque tube. Note that the spray deflector is optional on the 717 model airplane. (Copyright Boeing. Used with permission.)(Modified by the NTSB for clarity.)

3.0 Normal Nose Landing Gear Actuation

The nose landing gear moves down and aft, approximately 90 degrees, for full extension. The nose landing gear actuation system uses pressure from the right hydraulic system. The landing gear control lever, located in the flight deck, positions the landing gear control valve, which supplies hydraulic pressure to extend or retract the nose gear.¹ Hydraulic pressure also helps to hold the nose gear fully extended and retracted. Lock links also lock the nose landing gear in the fully up and fully down positions.

For nose gear extend and retract operations, hydraulic pressure goes to the nose gear bungee and retract cylinders. The nose gear bungee cylinder attaches to a fitting on the aft bulkhead in the wheel well and to the upper lock link by a lever. The bungee cylinder applies force to the upper lock link to either move and hold the lock links in a locked position, or to pull the lock links out from a locked position.

The nose landing gear hydraulic retract cylinder (referred to as the nose gear actuating cylinder in Figure 3) connects between the gear strut housing and the wheel well structure. During gear extension, the retract cylinder will retract to move the gear to the down position, and will remain pressurized to hold the gear in the down position. If hydraulics are turned off, the actuator may slowly bleed pressure, but the actuator will repressurize when hydraulics are turned back on. During gear retraction, the retract actuator will extend to lift the gear, and will remain pressurized to hold the gear in the up position.

The nose landing gear forward doors operate mechanically by a linkage that connects to door drive cranks on the upper drag link. The first movement of the nose gear during retract or extend opens the forward gear doors by these mechanical linkages. The same linkages close the forward gear doors as the gear goes fully up or down. The aft doors connect directly to the gear strut by drive rods and are also driven by gear movement.

4.0 Alternate Nose Landing Gear Extension

The alternate landing gear extension control lever is on the flight deck floor, adjacent to the right side of the pedestal. The normal position of the lever is down. When the lever is pulled up, a cable system sets the landing gear control valve to bypass hydraulic pressure and moves the nose landing gear alternate uplock release mechanism.² The release mechanism moves the nose landing gear lower over-center lock link and releases the nose gear. The nose landing gear can then extend by free-

¹ The landing gear control valve position also controls the main landing gear extension and retraction. The operation of the main landing gear is not discussed in this report.

² The alternate landing gear extension control lever also initiates the alternate extension of the main landing gear. The alternate extension of the main landing gear is not discussed in this report.

fall. The nose landing gear doors open and close with the gear movement in the same manner as when the gear is extended normally. After extension, the nose gear mechanically locks in the down position

A mechanical latch mechanism holds the alternate landing gear extension control lever up after operation. The bypass position of the landing gear control valve prevents subsequent gear operation by hydraulic pressure. The mechanical latch can be released allowing the lever to be pushed back down.

5.0 Landing Gear Position Indicating

The landing gear position indicating system supplies necessary data by an electronic Proximity Sensing Electronics Unit (PSEU). The PSEU monitors the landing gear proximity sensors and the landing gear control lever position interlock. The PSEU also operates the lights in the landing gear position indicator in the flight deck. There are proximity sensors for the main and nose landing gear, and for the main gear inboard doors. For the nose landing gear, there are two redundant proximity sensors on the torque tube to show the gear is in the down position, and there are two redundant proximity sensors on the lock links to show the gear is in the fully down or fully up locked condition. The PSEU operates each sensor independently to sense a near, or far, target condition.

The landing gear position indicator is above the systems display in the flight deck, near the center of the main instrument panel. It contains lamps that illuminate to show green (safe) and red (not safe) gear conditions. The indicator lamps are under lenses with related placards for the LEFT, NOSE, and RIGHT gear locations.

D. DETAILS OF THE EXAMINATION

1.0 Aircraft Recovery

The Systems group convened on June 29, 2023, at Charlotte Douglas International Airport, to examine the accident airplane. The airplane landed without the nose landing gear in the down and locked position and the airplane came to rest on the runway centerline (see Figure 4). On June 28, 2023, Delta Air Lines Inc., in coordination with the NTSB via phone and with the FAA Charlotte Flight Standards District Office (FSDO) on-scene, recovered the aircraft from the runway to a maintenance ramp. A NTSB representative arrived at the airport at approximately 6:00pm EDT on June 28, at which time the aircraft was being towed from the runway.

A FAA Charlotte FSDO representative who was on-scene during the aircraft recovery from the runway provided the following statement about the activities that occurred prior to NTSB arrival:

"On 6/28/2023 at approximately 1659 local time, after the nose of N955AT was initially being raised off the ground, [we] witnessed the nose gear doors open and the nose gear slightly extend to the point where the tires extended about an inch below the lower line of the nose section of the aircraft. It did not travel any further. Maintenance found that the over center lock had broken preventing the nose gear from moving any further. After coordination with NTSB and DALA [Delta Air Lines Inc.], it was agreed to attempt to lower the gear by the pilot alternate extension procedure using the gear unsafe checklist. DALA mechanics followed the procedure but the nose gear was unable to move. After further coordination, it was determined to remove the damaged part [lower half of upper lock link] so that the gear could come down and be towed to the ramp with the nose gear down as this was determined to be the safest option. But since the nose gear could not be pinned down due to the broken part the gear needed to be raised and gear doors closed so it could be laid on the flatbed cart to be moved off the runway as this was now the safest option."



Figure 4: Aircraft on runway following the accident landing. (Photograph used with permission from the FAA)

2.0 Observed Damage

See Figure 5 for a fuselage station (FS) reference diagram to assist with the following damage description. The lower fuselage skin and lower fuselage doors from about FS 68 to FS 180 exhibited heavy abrasion damage from contact with the runway (see Figure 6). At FS 180 there was a slight buckle observed in the skin on the bottom side of the fuselage. The electronics bay door and the forward and aft nose landing gear doors were significantly damaged; however, as noted later in this report, still functioned normally. In addition, the Air Traffic Control 1 antenna located at FS 170, Marker Beacon antenna located at FS 190, drain mast located at FS 218, and Very High Frequency 1 antenna located at FS 294 all demonstrated damage consistent with the nose gear up landing.

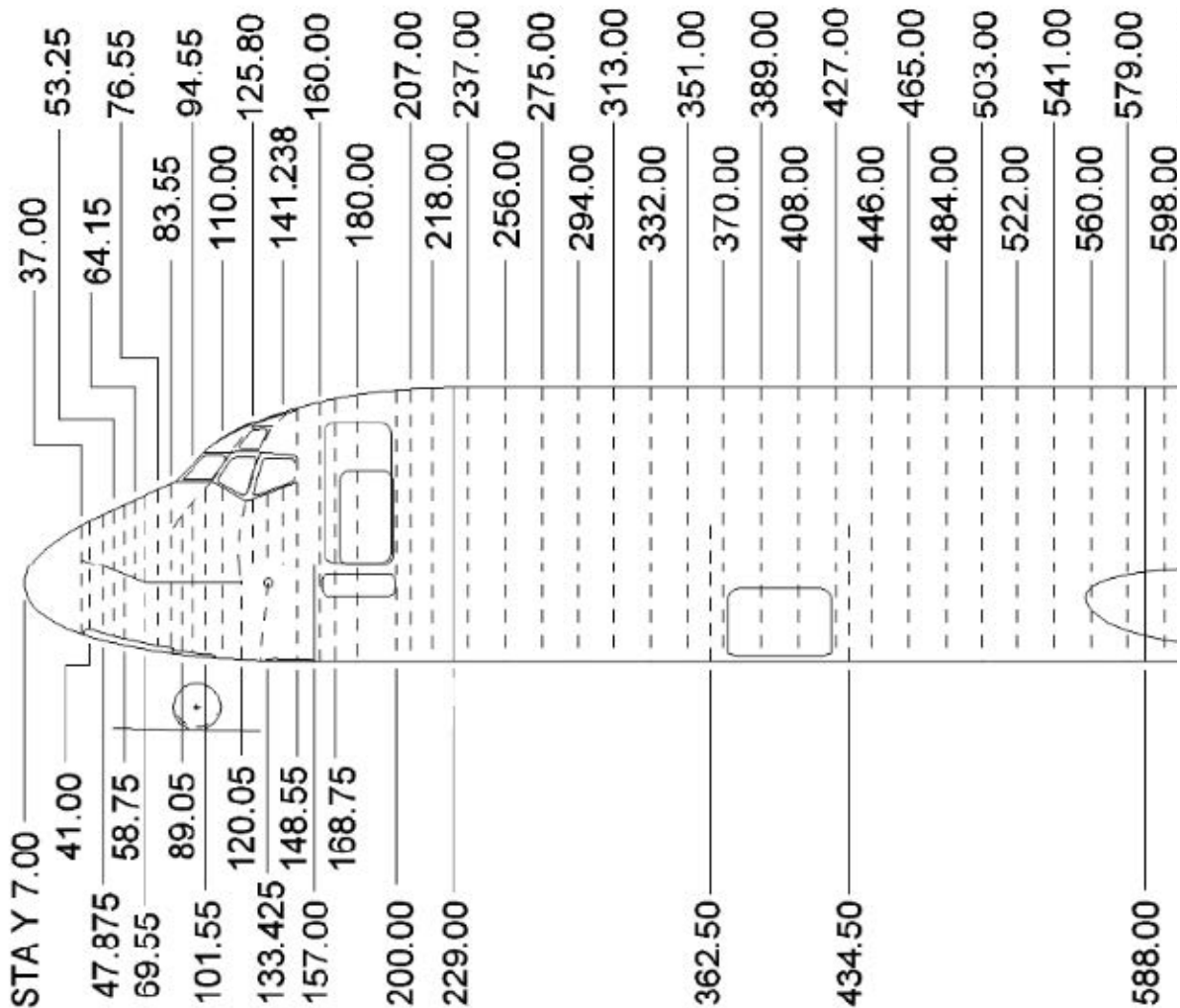


Figure 5: Boeing 717 fuselage station reference diagram. (Copyright Boeing. Used with permission.)



Figure 6: Abrasion damage to the lower fuselage skin, frames, and doors (view is looking forward towards nose).

3.0 Cockpit Configuration

The cockpit was documented following aircraft recovery. The maintenance personnel who performed the recovery stated that there were no maintenance messages on the Engine and Alert Display following the accident landing. It was also reported that the crew performed the Emergency Evacuation checklist prior to leaving the aircraft. The following was observed on June 29, 2023:

- Alternate extension handle was found stowed. The handle was pulled during recovery and the maintainer who operated it stated that it felt normal, and the handle operated as expected.
- Landing gear control lever was UP
- Left and right pack switches were OFF
- Cabin pressure system switch was selected to MANUAL ("MANUAL" light was illuminated)
- Outflow valve was in the center position
- Spoilers were retracted
- Flaps were set to 25°
- APU switch was OFF
- Fuel cutout switches were OFF
- Stabilizer trim was set to 8.9 ANU (aircraft nose up)
- Aileron trim was neutral
- Rudder trim was neutral
- All hydraulic pumps (left, right, transfer, and auxiliary) were ON
- The ground proximity terrain override switch was not illuminated
- The flap override switch was in the NORM position with the guard down (guard was protecting switch position)
- Fire handles were stowed (maintenance stated they were originally pulled out, but they pushed them in during recovery)
- All fuel boost pump switches were OFF (temporary sticker next to forward right boost pump switch referenced log page 4936513 – see section D.5 of this report)

The following circuit breakers were open and collard (all circuit breaker locations are on the electrical power center unless otherwise noted):

Cabin Pressure Control Panel (A14 – overhead circuit breaker panel)
Autopilot and Alternate Longitudinal Trim Phase A (D9)
Autopilot and Alternate Longitudinal Trim Phase B (D10)
Autopilot and Alternate Longitudinal Trim Phase C (D11)
Ground Proximity Warning System (F20)
Left Ground Control Relay (K32)
Right Ground Control Relay (L32)
Center Windshield Anti-Ice (X25)

Window Anti-Fog Captain, First Officer, and Center (X26)

The following circuit breakers were open. Some were collard as noted below. Maintenance stated that all these circuit breakers were pulled open to facilitate the recovery effort. All circuit breaker locations are on the electrical power center unless otherwise noted.

- Captain Pitot Heater (C12 - overhead circuit breaker panel)
- Cockpit Voice Recorder (F6) collard
- Flight Recorder (F21) collard
- Auxiliary Pitot Heat (M27)
- First Officer Pitot Heat (N27)
- Left Static Port Heat (X21) collard
- Left Angle of Attack Vane Heat (X22) collard
- Forward Drain Mast Heat (X27) collard
- Right Static Port Heat (Z21) collard
- Right Angle of Attack Vane Heat (Z22) collard
- Aft Drain Mast Heat (Z27) collard
- Ram Air Temp Probe Heat (Z29)
- Rudder Q Limiter Heat (Z30)

The Forward Right Fuel Tank Boost Pump (H19 - electrical power center) circuit breaker was open and collard with a tag that stated "INOP". Per the Minimum Equipment List, this circuit breaker should be pulled open and secured if the forward right fuel tank boost pump is deferred. There were no other open circuit breakers identified.

4.0 Nose Landing Gear Examination

During the recovery effort maintenance found that the nose landing gear upper lock link was fractured in half. Maintenance removed the lower half of the upper lock link during the recovery to facilitate getting the gear down. To facilitate the removal of the lower half of the upper lock link, maintenance had to cut the wires going to the attached proximity switches.

After the aircraft was removed from the runway, the main landing gear was locked out with gear pins and the nose of the aircraft was placed on a jack. The gear handle was moved to the down position, but the gear only came down slightly (axles approximately in line with the bottom of the fuselage). It was observed that because the upper lock link was fractured (see Figure 7), the lower lock link was free to swing down to a vertical position and was making contact with the top of the landing gear assembly, preventing the gear from extending (see Figure 8). There was scratched paint on the upper surface of the landing gear assembly in the area where the lower lock link was making contact.



Figure 7: Fractured upper lock link.

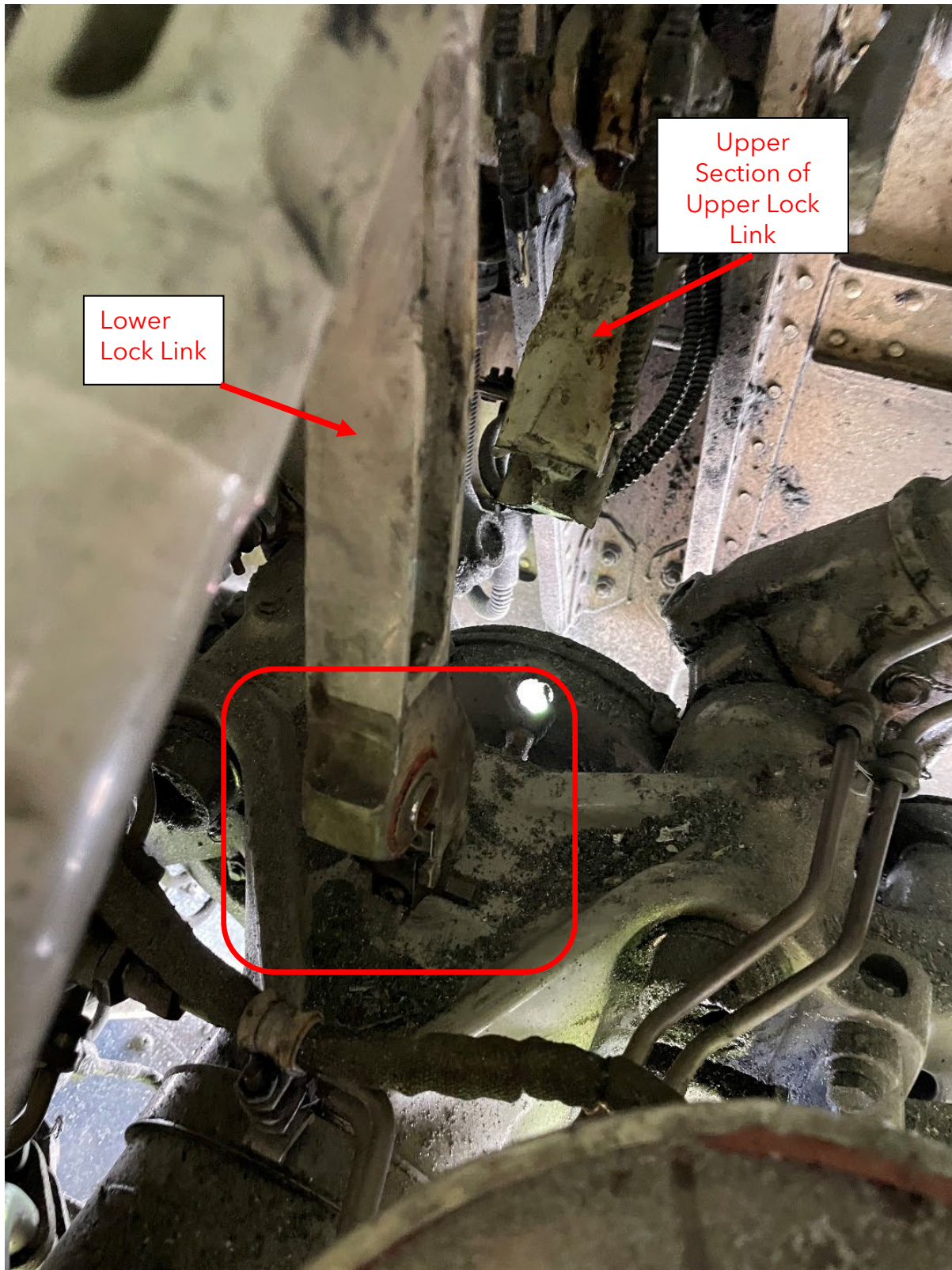


Figure 8: Lower lock link contacting nose gear assembly in foreground. The upper section of the severed upper lock link is in the background. View looking down and aft.

Except for the fractured upper lock link there were no concerning anomalies identified with the nose landing gear assembly. The bungee springs were intact and attached at both ends. The drag links were connected and the center joint was free to pivot with hand force. The grease fitting for the right side bearing on the lower drag brace fork end was missing. The bungee cylinder and retract actuators were intact, connected, and there were no indications of hydraulic leaks at the connections. The alternate extension handle was pulled and the release mechanism cam in the nose wheel well was observed to rotate slightly more than 90° down. The wheel well and gear were examined for any indications of a canted nose wheel and none were identified. This is consistent with the observations that during aircraft recovery from the runway the nose gear wheels were found in a straight orientation (see Figure 9). The landing gear control valve (located in the right main gear wheel well) was intact, connected, and there were no indications of hydraulic leaks at the connections.



Figure 9: Nose gear wheel position during aircraft recovery from the runway.
(Photograph used with permission from the FAA)

The auxiliary hydraulic pump was activated, and, with the landing gear handle, the gear was retracted to the full up position. The lower lock link was secured out of the way. The landing gear handle was moved to the down position and the nose landing gear then extended to the full down position. The upper section of the upper lock link was removed, and a new upper lock link was installed. The shims from the original lock link were used to install the new lock link. The gear was then operated up, down, up using the normal gear extension handle. The nose gear and nose gear doors operated with no anomalies observed. The nose gear doors operated in the correct sequence. The alternate extension handle was then pulled and the nose gear deployed with no anomalies observed. The alternate gear extension handle was stowed and the nose gear was cycled normally. The nose gear was then pinned in the extended position.

The following nose landing gear component label information was recorded:

Landing Gear Shock Strut Assembly

P/N: 5940497-501

Rework P/N: SR95320014-7001

Rework P/N: SR95320014-7003

S/N: UNJ-063

Upper Lock Link

P/N: 3914464-509V

S/N: 0007

A separate part number was struck through but was unreadable on-scene.

A bushing was observed in the upper attachment end that was not observed on the replacement lock link.

Lower Lock Link

P/N: 3913968-13

S/N: CPI1771

Landing Gear Bungee Cylinder

P/N: 5951639-5?01 (? = unreadable)

S/N: EFS-38782

Landing Gear Retract Actuator

P/N: 3928137-5001

S/N: EFS-35206

Landing Gear Control Valve

P/N: 5916460-5509

S/N: EFS-38097

5.0 Aircraft Maintenance Logbook

The maintenance logbook found in the aircraft held log pages dating back to May 28, 2023. Log page 4936513 recorded that MEL deferral 28-22-01 for the forward right boost pump was active. No other MEL/CDL deferrals were recorded as active. A cursory review of the logbook did not identify any other anomalies expected of contributing to the accident. More information can be found in the Maintenance Group Chair's Factual Report, which can be located in the public docket for this accident.

Submitted by:
Adam Huray
Aircraft Systems Investigator