



National Transportation Safety Board Aviation Incident Final Report

Location:	Newark, NJ	Incident Number:	DCA10IA021
Date & Time:	01/10/2010, 0915 EST	Registration:	N816UA
Aircraft:	AIRBUS INDUSTRIE A319-131	Aircraft Damage:	Minor
Defining Event:	Sys/Comp malf/fail (non-power)	Injuries:	3 Minor, 50 None
Flight Conducted Under:	Part 121: Air Carrier - Scheduled		

Analysis

Crew statements and recorded flight data indicate the flight was normal from the departure from Chicago until the first officer selected gear down while on final approach to runway 4R. There were no relevant open maintenance items on the airplane, and all applicable airworthiness directives had been complied with. After the landing gear was selected down during approach to runway 4R, the flight crew observed a warning indicating that one or more of the main landing gear (MLG) was not down and locked and one or more gear doors were not closed. The crew executed a go-around and cycled the landing gear handle in accordance with the electronic checklist. After cycling the landing gear, the warning remained and still indicated that one or more of the MLG was not down and locked and one or more gear doors were not closed. The flight crew coordinated with ATC for delaying vectors and continued to follow the abnormal procedures checklists in an attempt to extend the MLG. The United Airlines A320 Landing Gear Unsafe Indication After Extension checklist referred to the Landing Gear Gravity Extension checklist, which concluded that if the extension was unsuccessful the user was referred back to the Landing Gear Unsafe Indication After Extension. Although the flight crew reported that the checklists were confusing, they were able to accomplish all of the specified actions on the Landing Gear - Partial Gear or Gear Up Landing checklist in an attempt to rectify the MLG problem and prepare for landing. The first officer attempted to get assistance from United's maintenance control, but a difficulty with radio communications prevented effective assistance. After the incident, United amended their checklists for clarity.

After completing the checklist items without success, the flight crew coordinated with ATC for a partial gear-up landing on runway 4L at EWR. During approach, the crew discussed when the engines should be shut down. The Landing Gear - Partial Gear or Gear Up Landing checklist specified that if one MLG indicated abnormal both engines should be shut down "at touchdown", and if both MLG indicated abnormal the engines should be shut down "...in the flare, before touchdown." Just prior to touchdown, the Captain acknowledged the correct checklist instruction, but called for the engines to be shut down prior to touchdown. Although not contributory to the landing gear issue, shutting down the engines, and the concurrent loss of electrical generators without the auxiliary power unit running, would result in a loss of

various capabilities including nosewheel steering, anti-skid, and some spoiler capability. The airplane's speed at this time would be too low to provide electrical power from the Ram Air Turbine as well. Operation of the fuel cut-off switches and loss of electrical power resulted in the flight data recorder and cockpit voice recorder shutting down prior to touchdown. The loss of power did not affect the cabin emergency lighting.

Post incident examination of the airplane revealed that the right MLG door actuator had failed to extend the door to its fully open position. The partially open door obstructed the right MLG from extending to its down and locked position. The outboard tire of the right MLG was found resting on the top of the door assembly.

Examination of the door actuator revealed that some of its internal components had failed, one of them producing large quantities of fragmented metallic debris that collected in one location between the piston and the cylinder with smaller particles being embedded in the piston seals. Testing of the actuator revealed that it took more pressure than normal to initiate extension and retraction and it is considered likely that, under the right conditions, the debris might prevent the piston from moving in the cylinder. Although the majority of the debris remained within the cylinder, smaller particles were able to migrate through the actuator's retract line, coming to rest in the retract restrictor and its mounting block. This debris likely restricted the flow of fluid through the actuator which would reduce the speed of extension and retraction, allowing the main gear tire to contact the door and preventing further motion of the gear and door.

During the evacuation, the 1R door did not fully open and only 1/8 of the 1R emergency evacuation slide dropped from the pack after the 1R door was opened. Prior to the flight the purser said she felt resistance when she armed the 1R door. Review of the photographs taken of the 1R slide following the incident, revealed that the 1R evacuation slide remained jammed inside its pack, and the girt was caught between the pack and the girt bar, preventing the 1R door from fully opening. Further, no anomalies were found with the 1R power assist actuator. According to the slide manufacturer, improper stowage of the girt bar in the floor brackets and/or improper packing of the evacuation slide can result in excessive bulk at the bottom of the slide pack and may impact the orientation of the slide pack at the initial stages of the deployment sequence. Because no mechanical deficiencies were found with the door, slide or girt bar, the likely reason for the lack of deployment of the 1R slide was improper packing of the 1R slide. The loss of availability of the 1R door and slide did not negatively impact the evacuation.

Probable Cause and Findings

The National Transportation Safety Board determines the probable cause(s) of this incident to be: A mechanical failure of internal components of the right main landing gear door actuator resulting in the flight crew being unable to fully extend the right main landing gear using the normal and alternate procedures.

Contributing to this incident was a circular reference in the company Flight Manual in which the Landing Gear Gravity Extension checklist referred back to the Landing Gear Unsafe Indication After Extension checklist rather than the Landing Gear - Partial Gear or Gear Up

Landing checklist.

Findings

Aircraft	Landing gear door actuator - Malfunction (Cause) Electrical power system - Incorrect use/operation Data recorders (flight/maint) - Capability exceeded
Organizational issues	Design of document/info - Operator

Factual Information

HISTORY OF FLIGHT

On January 10, 2010 at 0915 EST, an Airbus A319, registration N816UA, operated by United Airlines as flight 634, landed with the right main gear partially extended on runway 4 left (4L) at the Newark Liberty International Airport, Newark, NJ (EWR). The airplane was on a regularly scheduled flight from Chicago O'Hare Airport. While on approach to EWR the crew attempted to extend the landing gear and observed an abnormal gear indication. The crew conducted a go-around and attempted to manually extend the gear, but was not able to extend and lock the right main gear, and decided to land before fuel ran low. The flight landed on runway 4L, coming to rest on the left main and nose wheel, and the right engine nacelle. The airplane had minor damage to the underside of the right nacelle and right and left gear doors. Three of the 48 passengers received minor injuries during the evacuation, and none of the 5 crew were injured.

The flight to EWR was reported as routine, with clear and cold weather and light traffic prevailing in the terminal area. The First Officer (FO) was the pilot flying and called for the gear to be extended just outside of the final approach fix on the instrument landing system (ILS) approach to runway 4 right (4R). At about 0837, the Captain selected the landing gear down, however the landing gear indication lights remained red, indicating that the gear was not in the down and locked position. The crew received a Master Warning and electronic centralized aircraft monitoring (ECAM) messages indicating that one or more of the main landing gear was not down and locked and one or more gear doors were not closed. The crew performed a go-around and advised air traffic control (ATC). All other airplane systems, including hydraulics were indicating normal prior to the go-around. The FO completed the go-around maneuver and the landing gear handle was cycled in accordance with the ECAM checklist item. The landing gear indicator lights remained red. The Captain took control of the airplane and radio while the FO continued to accomplish the next action item, gravity extension of the gear. Air Traffic Control (ATC) vectored the flight on a wide left hand traffic pattern to the west of the airport. The Captain noted fuel on board as 4,800 pounds.

At about 0841, following the gravity extension procedure, the landing gear panel lights annunciating left main gear and the nose gear showed green, but the right main gear light remained red. The crew reported that the checklists were confusing with circular references. The pilots then referred to the PARTIAL GEAR OR GEAR UP LANDING checklist in the Irregular Procedures chapter.

Flight Operations procedures at United Airlines were based on the manufacturer's guidance and modified to meet operational needs. Airbus A319/A320 flight crews at United Airlines carried a company produced A319/A320 Flight Manual on the flight deck in lieu of the QRH (Quick Reference Handbook) provided by the manufacturer. The A319/A320 Flight Manual contained an Emergency Procedures chapter and an Irregular Procedures chapter that included both ECAM (Electronic Centralized Aircraft Monitoring) and non-ECAM procedures.

The Irregular Procedures chapter included a Landing Gear Unsafe Indication After Extension procedure which referred to the Landing Gear Gravity Extension procedure. A circular reference existed as, at the completion of the Landing Gear Gravity Extension checklist, if the extension was unsuccessful; the user was referred back to the Landing Gear Unsafe Indication After Extension procedure.

The circular reference did not exist in the Airbus QRH as the Landing Gear Gravity Extension procedure included a step referring to the Landing with Abnormal L/G procedure, which was also contained in the QRH.

The Irregular Procedures chapter of the United A319/A320 Flight Manual did not include the Landing with Abnormal L/G procedure but included a similar procedure entitled Landing Gear - Partial Gear or Gear Up Landing.

Between 0844 and 0852, the Captain had control of the airplane and coordinated with ATC for delaying and positioning vectors, while coordinating with the cabin crew to prepare for a possible gear-up landing. During the same time period, the FO was performing the checklist steps and attempting to coordinate with United System Aircraft Maintenance Control and other maintenance support for assistance with the gear problem.

The Captain requested a visual inspection of the landing gear from EWR tower personnel. ATC vectored the flight to the ILS runway 11 for a fly over to allow the tower cab personnel an opportunity to view the landing gear. At about 0854, as the airplane was approaching runway 11, the tower controller radioed that the airplane's left main and nose gear looked down, but that the right landing gear "did not look right." The Captain requested radar vectors to set up for landing on the longest runway, runway 4L, and to complete the landing with abnormal gear checklist. ATC vectored the flight northwest of the airport and advised the crew they could plan to land on runway 4L when ready. The Captain declared an emergency and requested fire/rescue equipment.

The Captain contacted the flight attendants and informed them of the situation and told them to prepare for an evacuation. They prepared the cabin for landing and made an announcement over the public address system that there would be an emergency evacuation after they landed. The Purser identified a deadheading flight attendant from another airline and repositioned him in order to help open the over wing exits after the airplane landed. Additionally, she asked a first class passenger to assist her with the 1R door if needed.

As the aircraft was vectored along a left downwind leg abeam EWR airport, the FO briefed the Captain on the checklist items. They determined there was sufficient fuel to execute another go-around and landing if necessary. At about 0904, the crew advised ATC they were ready to make a landing on runway 4L, and the Captain stated "if we need more time, we'll make a 360 [degree turn]." ATC vectored the airplane to a standard left base and intercept to the final approach. While on final approach, at about 0909, the Captain elected to execute a 360 degree turn in order to ensure all actions were taken and the flight attendants, passengers and airport rescue and firefighting (ARFF) were provided adequate time to prepare for the emergency landing.

The visual approach to runway 4L was flown with the autopilot and auto-thrust off. In the flare, just prior to touchdown, the Captain called for the engines to be shutdown. The United Airlines Irregular Procedures Landing Gear - Partial Gear or Gear Up Landing checklist specified that if one main landing gear indicated abnormal both engines should be shut "at touchdown", and if both main landing gear indicated abnormal the engines should be shut down "...in the flare, before touchdown." However, the crew discussed when to shut down the engines numerous times during the preparation for the landing. On final approach, the FO read the checklist item "engine master switch is off at touchdown," but just prior to landing at 0914:15 the Captain said, "you wanna get those engines, ya think, now?" The FO said "at

touchdown it says." The Captain acknowledged but said "get 'em now, we don't need 'em."

The Captain reported he made a normal touchdown on the left main landing gear and held the right wing off the ground as long as possible. The initial touchdown marks appeared just abeam the intersection with taxiway C, and Port Authority personnel measured scrape marks approximately 300 feet beyond the initial point. The right engine nacelle settled to the runway and the pilots reported very little drag initially. The Captain said he applied very light left brake which he quickly released after determining rudder control provided full directional control authority. As the airplane slowed, he reported there was more pronounced drag and tendency to pull to the right during the final seconds of the deceleration. The airplane came to rest on runway centerline, about 3,400 feet from the initial touchdown.

After the airplane came to rest the Purser activated the evacuation alarm and the flight attendants provided the passengers with verbal commands to evacuate the cabin. The passengers exited the airplane using the evacuation slides at both the left and right over-wing exits, door 1L, door 2L and door 2R. The Purser opened the 1L door and observed many passengers evacuated out the 1L exit and gathered along the left side of the airplane.

After the Purser opened the 1L door she went to the 1R door. The first class passenger was attempting to open the 1R door, and she witnessed his hand move the handle but it did not appear to go all the way up. When the door opened it appeared to open differently than the other door (1L) and it looked "cockeyed" from where the Purser stood. The first class passenger who opened the 1R door stated it opened about 75 percent of the way and he did not hear any noise coming from the emergency evacuation slide nor did the slide deploy. The Purser directed the passenger to evacuate via the 1L door and blocked the 1R to prevent other passengers from exiting that way. Shortly afterward the passenger evacuation was complete, and the flight attendants exited the doors at their evacuation stations. The pilots initiated the evacuation checklist and exited out the cockpit door. The pilots stated when they exited the cockpit there was no one remaining in the cabin. The Captain and FO conducted a walkthrough of the cabin to ensure all passengers and crew had departed. Both pilots evacuated the cabin using door 1L evacuation slide.

INJURIES TO PERSONS

Three of the 48 passengers received minor injuries during the evacuation. The injured passengers were seen by EMT's at the site and refused further treatment.

DAMAGE TO AIRCRAFT

The airplane sustained minor damage to the right engine nacelle, fan cowl, and thrust reverser; and right and left main gear doors from impact and abrasion on the runway pavement. The right engine drain mast and support structure, and the right engine integrated drive generator sustained minor abrasion damage. The right main gear door actuator was removed and examined (see Tests and Research). The damaged components were repaired or replaced in accordance with manufacturer instructions, and with FAA authorization, the airplane was returned to service.

OTHER DAMAGE

The gear doors and right nacelle created gouges in the runway surface.

PERSONNEL INFORMATION

The captain, age 41, had worked for United Airlines since July 16, 1990. He held an Airline Transport Pilot certificate, multi-engine land, with type ratings in A320, B737 and B767. The A319 is a variant of the A320 and does not require a separate FAA type rating on the pilot's certificate. He held an FAA first class medical certificate with no limitations or waivers. Company records indicate that he had 14,000 hours total time with 915 hours on the A319. He had no previous accidents, incidents, or violations. The incident flight was the first flight of the day for the Captain.

The first officer, age 46, had worked for United Airlines since July 29, 1996. He held an Airline Transport Pilot certificate, multi-engine land, with type ratings in the A320, B737, and B767. He held an FAA first class medical certificate with no limitations or waivers. He reported a total of 15,000 flight hours, with 240 hours in the A320. The incident flight was the first flight of the day for the FO.

The three flight attendants were all current and qualified on the Airbus A319.

AIRCRAFT INFORMATION

N816UA, manufacturer serial number 871, United Airlines ship number 4016, was an Airbus Industrie A319-100 equipped with IAE Aerospace V2522 engines. The airplane had accumulated approximately 39,679 hours total time on the airframe. Recorded data and airline records indicated no relevant maintenance issues with the airplane. At the time of the accident the estimated landing weight was 108,120 pounds with a center of gravity at 29.6% mean aerodynamic chord. During recovery, it was noted that fuel indicated approximately 600 pounds in the left tank, 120 pound in the center tank and 880 pounds in the right tank, for a total of 1,600 pounds of fuel remaining.

The landing gear control system consists of a forward retracting nose gear and two inboard retracting main gears. The gear and their associated doors are electrically sensed and hydraulically operated. The landing gear control and sequencing is electrically achieved with the use of proximity sensors and two independent Landing Gear Control and Interface Units (LGCIU) computers. The LGCIUs provide sequencing commands to the various components to extend or retract the landing gear and doors.

When the active LGCIU detects that the gear selector lever is in the down position, it commands the door selector valve to open, unlocking and opening all three landing gear doors. If a door has not reached its fully open position within four seconds of the first door reaching its fully open position, a fault will be recorded within the LGCIU. This fault is not displayed to the crew. If both LGCIUs detect that at least one gear does not fully extend and lock in place within 30 seconds of the movement of the landing gear selector, the crew will receive a red warning "LG GEAR NOT DOWNLOCKED" on the ECAM, associated with a flashing Master Warning light and a continuous repetitive chime.

Whenever the landing gear extension sequence is not completed, an ECAM warning is triggered instructing the flight crew to recycle the gear (i.e. moving the landing gear selector lever up then down again). If the landing gear still does not extend, a "gravity extension" (free-fall) should be accomplished. The landing gear gravity extension should be performed in accordance with the QRH, however during the incident, the crew expressed some confusion over the correct steps following the completion of the gravity extension checklist, without successfully locking down the main gear.

Rotating the free-fall extension-handle activates the free fall system. The free-fall extension-

handle is located at the rear of the cockpit center pedestal. A system of rods, cables and bellcranks connect the free-fall extension-handle to: the landing gear door up-locks, the landing gear up-locks, two hydraulic vent valves and one hydraulic cut-out valve. When the free-fall extension-handle is turned, uplocks are released and the landing gear doors are opened by the weight of landing gear and aerodynamic force. Gravity extends the landing gears, which are then held and locked in the extended position by their respective MLG downlock mechanism. When the landing gear is extended by the free-fall system, the landing gear doors stay open.

There is no special indication for the position of the landing gear in the free-fall extension mode. The landing gear doors will show OPEN (amber indication) when the free-fall extension system is used. The other indications in the cockpit are the same as those for the normal extension and retraction system.

The main landing gear door actuator includes a cylinder and piston rod. The cylinder is closed at one end by an end fitting sub-assembly and at the other end by a damping housing and piston rod. Both the end fitting sub-assembly and damping housing are of similar design, inside the cylinder; however the end fitting sub-assembly has two damping holes in line and staggered axially, while the damping housing has two holes diametrically opposite and staggered axially. Therefore both the end fitting sub-assembly and housing damping provide progressive damping. The inner ends of the end fitting sub-assembly and damping housing are lipped toward the cylinder wall, and have two cut outs to permit fluid flow.

When commanded to extend, the actuator receives hydraulic pressure (3,000 psi) at its extend port. This pressure reacts against the piston head resulting in the piston rod extending. As the piston rod approaches the extended position, the piston rod (including the damping ring) enters the counter bore in the damping housing, leaving the damping holes and the slot in the damping ring as the exit ports for the hydraulic fluid. The piston rod is slowed as the pressure within the damping housing intensifies. Once the damping ring has passed the inner most damping hole, the flow is further restricted, until the flange of the piston rod head comes to rest against the end of the damping housing. When commanded to retract, the actuator receives hydraulic pressure at its retract port, and operates similarly to extension but in the opposite direction, until the flange of the piston rod head comes to rest against the damping housing lip or movement of the actuator is prevented by the landing gear door mechanical stops.

A review of maintenance data provided by United Airlines revealed that United Airlines was in compliance with the requirements of FAA Airworthiness Directive (AD) 2007-06-18 at the time of the incident (see Additional Information section for details of the AD). According to the records, the landing gear door actuators were inspected 421 flight cycles prior to the incident on October 2, 2009. No malfunctions were identified with the actuators during the inspection. At the time of the inspection, the airplane had accumulated a total of 38,721 flight hours and 14,964 flight cycles.

METEOROLOGICAL INFORMATION

The Newark Airport 08:51 EDT weather observation indicated clear conditions with 10 miles visibility, wind from 340 degrees at 7 knots, temperature -9° C. There was no precipitation.

AIDS TO NAVIGATION

The instrument landing system (ILS) runway 4L indicated no anomalies.

COMMUNICATIONS

No communications problems with ATC were noted at any time during the incident sequence. While executing the irregular procedures checklists, the FO attempted to contact United's Flight Dispatch and System Aircraft Maintenance Control (note on the CVR transcript the pilots term this "Sam" in speech, it is not an individual) to advise them of the situation and to request any additional guidance, but he had difficulty establishing communications which he attributed to radio limitations at low altitude.

AERODROME INFORMATION

The Newark Liberty International Airport is located approximately 3 miles south of the city of Newark, N.J. The airport averages over 1,100 operations per day, mostly air carrier and air taxi activity. Runway 4L is 11,000 feet long and 150 feet wide, aligned to 039 degrees magnetic. Touchdown zone elevation is 10 feet above sea level, and the arrival threshold is displaced 2,540 feet. The runway is marked for precision instrument operations, has in-pavement centerline and touchdown zone lighting, and is equipped with a 1,400 foot medium intensity approach lighting system with runway alignment indicator lights. There is a 4-light Precision Approach Path Indicator (PAPI) system to the left of the runway. A full instrument landing system serves the runway. The runway has no significant obstacles and was dry at the time of the accident.

FLIGHT RECORDERS

The Digital Flight Data Recorder file was provided to the NTSB by the operator, United Airlines. The download from the recorder on the event aircraft consisted of over 54 hours of data. The data shows that the gear were initially selected down at 08:37:15 and there was a resulting gear "not downlocked" indication followed by a Master Warning. The FDR recorded several unsuccessful attempts to reset the gear and during the final approach, the Gear Down Locked parameter indicated "not locked down." The data ended around 09:14:29, at a recorded radio altitude of 4 feet, and an airspeed of 115 knots.

The Cockpit Voice Recorder was a Honeywell 6020 SSCVR 30, which recorded 30 minutes of digital audio stored in solid-state memory modules. Data older than 30 minutes are overwritten as the recording continues. The CVR had not sustained any heat or structural damage and the audio information was extracted from the recorder normally, without difficulty. The recording began at 0844:10 EST, approximately three minutes after the first flight deck indication of a landing gear anomaly. The recording ended at 0914:29 EST as the airplane was in the landing flare.

The FDR and CVR stopped recording just prior to touchdown of the event aircraft and did not capture the landing, rollout or emergency evacuation. On this A319 aircraft (SN 0871), the FDR received power from the 202XP Normal Bus which was on AC Bus 2, and the CVR was powered by the 801XP Bus, which was on the AC Shed Essential Bus. During the landing sequence in Newark, the right and left engines were shut down. The FDR, in normal operations, would stop recording when the last operating engine's HP fuel valve was commanded closed. Additionally, when the engines were shut down, the AC bus 2 would stop providing power to the 202XP Normal Bus. As a result of the engines being shutdown in the landing flare, the FDR stopped recording due to either the fuel valves closing or the power loss.

When there was a loss of engine and APU generated power on the A320, the Ram Air Turbine

(RAT) was designed to extend automatically. Above 100 knots, the RAT powered the blue hydraulic system, driving a hydraulic motor that provided power to the emergency generator. The emergency generator supplied power to the AC and DC Essential Busses. The AC Shed Essential Bus resided on the AC Essential Bus. When the airspeed decreased below 100 knots, the RAT would no longer drive the emergency generator per the electric system logic. As a result, the CVR, which is on the AC Shed Essential Bus, would lose power. For the event landing of N816UA, the last recorded airspeed on the FDR was 115 knots and the CVR stopped shortly thereafter. Even were the RAT to have had time to fully deploy before aircraft touchdown, the airspeed would not have been sufficient to provide power on the CVR via the emergency generator.

WRECKAGE INFORMATION

The right main landing gear was found partially extended at an angle of approximately 30 degrees from the fully retracted position and its outboard tire was found resting on the lateral ramp located on the inboard edge, in the center of the landing gear door. The door was found in a partially open position with the outboard edge resting on the runway surface. The right main gear sliding tube (shock absorber strut) was found fully extended. No damage was noted to the main gear assembly, brakes, tires, or strut mounted landing gear doors.

As the aircraft was lifted off the runway the right main landing gear door did not change position and rose with the aircraft fuselage. Maintenance technicians attempted to lower the door via the manual door opening control handle, by bleeding off the hydraulic reservoir head pressure, by attempting to bleed pressure from the lines, and by applying approximately 300 pounds of force in a downward direction on the landing gear door. None of the procedures had an effect on the landing gear door position.

The nitrogen charge was removed from the outboard main landing gear tire. The right main landing gear assembly was then jacked up to remove the weight of the landing gear from the landing gear door. After the lower attach bolt was removed from the right main landing gear door actuator, the landing gear door moved to the extended position. As the aircraft was lifted the right main landing gear was swung into position and a safety lock was installed. The aircraft was then towed from the runway area and recovered.

Before the airplane was moved to a hangar, a UAL Line Engineer secured the 1R door and emergency evacuation slide. After relieving pressure (300 p.s.i.) from the power assist actuator, the Line Engineer disengaged the girt bar from the door sill, and moved the portion of the evacuation slide hanging below the door sill, up inside the slide pack, and closed the 1R door. After closing the 1R door, the UAL Line Engineer removed the slide pack cover and installed a safety pin in the slide inflation cylinder. See Survival Aspects for details of the door and slide.

SURVIVAL ASPECTS

During the evacuation, the 1R door did not fully open and the emergency slide did not fully deploy nor did it inflate. In an interview, the Purser noted that she observed the first class passenger moving the handle "but it did not appear to go all the way up. He appeared to be fighting to force the door handle upwards." She did not see the 2D passenger touch the arm/disarm handle before he opened the 1R door, and neither she nor the 2D passenger pulled the manual inflation handle.

The passenger self-identified as a frequent flyer, was asked by the Purser to assist if needed. In

an interview, he stated that although he was not specifically directed to open the 1R door, he thought that opening this door would allow a faster evacuation of the cabin. He said he pulled the door handle up, and the door opened about 75 percent of the way. He did not hear any noise (coming from the emergency evacuation slide.) He looked down and saw the red triangle at the door sill. He knelt down and pulled the red handle, but still nothing happened. At that point the Purser directed him to go out the 1L exit.

The UAL Line Engineer stated he found the 1R door at approximately 3" from the fully open position. Investigators found the door arming lever in the armed position. The girt bar was attached to the door sill latches in the correct positions for an armed condition. The slide material connected to the girt bar was extended approximately 12" between the girt bar and the slide pack. This material was pulled tight between the girt bar and the bottom of the slide pack. The slide pack assembly was examined, removed, and shipped to the manufacturer for further examination and testing.

Under emergency conditions, the door is opened by movement of the door handle in the full up position. As the door opens, a power assist actuator on the door mechanically drives the door to its open position. When the door opens it moves up (clearing the door sill), outward (away from the fuselage), and forward until it comes to rest in front of the doorway and against a stop on the side of the fuselage. As the door moves up and outward, the release mechanism allows the slide pack to fall out of the packboard assembly and off the door. As the slide pack falls and drops below the door, the inflation cable tightens and opens the inflation valve which pressurizes and inflates the evacuation slide as it falls away from the door and unfolds.

Investigators examined the 1R door and emergency evacuation slide, and observed the evacuation slide remained contained within its pack. Examination of the inflation cable, slide release disk, and girt found no anomalies. The inflation cylinder was fully charged, and the slide release mechanism operated as designed. Review of the photographs taken on the date of the incident, showed that approximately 1/8 of the slide had dropped from the pack when the 1R door was opened during the emergency evacuation. Review of the 1R slide maintenance records revealed that they had been overhauled by Winslow Services, Inc. (Winslow) on May 13, 2009, and packed and returned to service in accordance with applicable directives.

The slide was disassembled at Air Cruisers manufacturing facility and unfolded (referencing the reverse Air Cruiser's packing procedures.) The slide was unfurled and neither packing inconsistencies nor discrepancies were observed. In addition, the slide was manually inflated without any discrepancies.

The door Power Assist Actuator, manufactured by Ratier-Figeac, was removed and examined at the manufacturer's facility under the supervision the Bureau d'Enquetes et d'Analyses and the participation of the investigative team. No anomalies were found.

A320/319 Emergency Evacuation History

According to an Airbus representative, the evacuation slides/rafts on the A320 series airplanes were successfully qualified for use on the most critical adverse attitude, which included: aircraft leaning back, one main gear down, one main gear up and aircraft resting on the engine. In addition, the slides and slide rafts were qualified to provide sufficient capability to evacuate passengers safely to the ground under all standard adverse attitudes.

Prior to the flight the purser had difficulty/resistance (stiff movement through the lower motion of the handle) when she armed the 1R door. Airbus issued Service Bulletin (SB) A320-

52-1085 regarding door cable replacement and lubrication on July 16, 1996 (revised September 16, 1996.) UAL records indicate that SB A320-52-1085 had been accomplished on aircraft N816UA (S/N 4016) during its manufacturer. In addition to SB A320-52-1085, the Air Cruisers representative stated there are two other conditions that could result in the door arming difficulties, or problems with the deployment of the evacuation slide. 1. The improper stowage of the girt in the floor brackets and, 2. An improperly packed evacuation slide that extends beyond the lower edge of the pack board, thereby contacting the cabin floor. Both conditions result in excessive bulk at the bottom of the slide pack and are known to lead to door arming difficulties. Also, the second condition (excess extension of slide pack beyond lower packboard edge) may have some impact on the orientation of the slide pack at the initial stages of the deployment sequence.

TESTS AND RESEARCH

Landing Gear Door Actuator

Investigators performed a visual examination of the airplane's two main landing gear doors and actuating mechanisms while the airplane was in a hangar at EWR. The right main gear door remained in a partially open position as compared to the left main gear door. Visual inspection of the door revealed that it had sustained damage (scrape and wear marks) on its upper and lower sides. The Dowty Aerospace door actuator remained connected to the door and to the airplane at its respective attachment locations. The length of the actuator (distance between the rod eye bearing centers) was measured and found to be about 36 3/4-inches, which was about four inches less than the length of the left door actuator. According to maintenance records, the actuator was originally installed on the airplane at the time of manufacture and had not been overhauled or modified per any service bulletins. After the actuator was removed from the aircraft, hand pressure revealed that the door moved up and down freely without binding or resistance. During this check, the ECAM wheel page was observed to indicate the correct door positions.

Prior to the actuator being tested and disassembled at the manufacturer, computed tomography (CT) scans of the actuator were conducted by Varian Medical Systems under the direction of NTSB staff. Investigators then conducted an examination/disassembly of the actuator at the GE Aviation facility located in Cheltenham, Gloucestershire United Kingdom.

Operational tests performed on the actuator revealed that the piston rod would initiate extension and retraction when hydraulic pressure was applied to the actuator although the pressure required was greater than what was considered normal.. Two restrictor sub-assemblies are installed in a housing block mounted at the rear of the actuator. The restrictor sub assemblies were removed from the actuator, disassembled and examined. Pieces of metallic debris were found inside retract restrictor and the housing block. The retract line between the front of the cylinder and the mounting block was found to be free of any debris.

The piston rod was removed from the cylinder by the application of hand pressure to the piston rod eye end. During the removal process, a large amount of metal debris (bronze and grey colored) came out of the cylinder. The grey debris was found to be magnetic (ferrous) and was separated from the bronze debris and weighed. The weight of the ferrous debris was approximately 8.8g, which equates to about 90% of the weight of a new damping ring (9.7g). The piston rod was observed to have impact damage at its shoulder and scrape marks on the retaining ring shoulder. The piston head was observed to have longitudinal scratch marks and

bruising on the extend stop face. Small particles of debris were observed embedded in the piston head backing rings and on the piston head seal.

ORGANIZATIONAL AND MANAGEMENT INFORMATION

United Airlines, Inc. was a subsidiary of UAL Corporation headquartered in Chicago, IL, and was certificated as a 14 CFR Part 121 air carrier for both domestic and flag operations. At the time of the incident, United Airlines had major hubs at Denver International Airport (DEN), Los Angeles International Airport (LAX), O'Hare International Airport (ORD), San Francisco International Airport (SFO), and Washington Dulles International Airport (IAD), and operated 359 airplanes manufactured by either Boeing or Airbus. The fleet consisted of approximately 55 Airbus A319 and approximately 97 Airbus A320 aircraft. The incident airplane was owned and operated by United Airlines, Inc., and approved for Part 121 passenger carrying operations.

Flight Operations procedures at United Airlines were based on the manufacturer's guidance. For the Airbus fleet, the main reference was the Airbus FCOM (Flight Crew Operating Manual). Procedures in the Airbus FCOM were used at United Airlines and some were modified to meet operational needs. Changes to the procedures were reviewed by the Fleet Technical Group who interfaced with Airbus North America. New procedures, and changes to procedures, were vetted by the Fleet Technical group and then reviewed and approved by the FAA Aircrew Program Manager (APM) and Principal Operations Inspector (POI) before being included in the United Airlines Flight Manual.

ADDITIONAL INFORMATION

Landing Gear Door Actuator History

On March 7, 2006 Airbus issued Service Bulletin (SB) A320-32-1309 to provide operators of A318/A319/A320 and A321 aircraft with instructions to perform inspections of the MLG door actuators. The SB states that initial inspections must be accomplished before accumulation of 3,000 Flight Cycles (FC) from first flight or within 800 flight cycles from the issue date of this service bulletin and to repeat the inspections at intervals not to exceed 900 flight cycles. Airbus released this SB because they had received several reports of in-service failures of the MLG door actuator. According to the SB, the symptoms of a failing door actuator are slow operation of the door opening/closing sequence, possibly leading to the generation of ECAM warnings of "L/G NOT DOWNLOCKED" and "L/G DOORS NOT CLOSED". The SB further stated that investigations by Airbus found that the affected MLG doors had been difficult to open manually (unusually high pressure was required to extend the actuator and consequently open the door). The MLG door actuator was confirmed to be the cause of the condition with a stiff action and reduced stroke. The damping ring and associated retaining ring are typically found broken with subsequent damage to the damping housing from the resultant debris. The high friction delays the whole LG extension/retraction sequence. The free-fall mode of the MLG could be impaired if friction was high enough.

On May 15, 2006, the European Aviation Safety Agency (EASA) issued Airworthiness Directive (AD) 2006-0112 to identify defective MLG door actuators. This AD required that operators of A318/A319/A320 and A321 aircraft check the opening sequence of the MLG doors and apply the associated corrective actions, if necessary, in accordance with the instructions provide in Airbus SB A320-32-1309 (original issue). The inspections are to be repeated at intervals not to exceed 900 flight cycles.

On June 19, 2006, Airbus issued SB A320-32-1309, Revision 01 to provide operators of

A318/A319/A320 and A321 aircraft. Revision 01 was issued to revise the accomplishment timescales and to delete one of the instructions to check the movement of the MLG doors when they are manually released. The revised timescale now states: "The initial inspection must be accomplished before the MLG door actuator has accumulated 3,000 FC since new or within the next 800 FC from the issue date of this Service Bulletin, whichever occurs later. Repeat inspections must be accomplished at every 900 FC."

On March 23, 2007, the FAA released AD 2007-06-18, mandating repetitive inspections of the operation of the MLG door opening sequence to determine if a defective actuator is installed, and replacing any defective actuator with a new actuator. This AD resulted from reports of slow operation of the MLG door opening/closing sequence due to a defective actuator. According to the AD, operators of all Airbus Model A318, A319, A320, and A321 airplanes must do a general visual inspection of the operation of the MLG door opening sequence to determine if a defective actuator is installed by doing all the applicable actions, including replacing the door actuator, as applicable, specified in the accomplishment instructions of Airbus SB A320-32-1309, Revision 01, dated June 19, 2006. The inspections are to be repeated at intervals not to exceed 900 flight cycles.

On July 22, 2008, Airbus issued SB A320-32-1338 to inform operators that GE Aviation has introduced a new MLG door actuator having part number (P/N) 114122012. Accomplishment of SB A320-32-1338 will cancel the MLG door repetitive inspections required by SB A320-32-1309. The new MLG door actuator incorporates an improved retaining ring and a modified piston rod to accommodate the thicker section of the improved retaining ring.

On October 17, 2008, EASA issued Airworthiness Directive (AD) 2006-0112R1. This AD revises and replaces EASA AD 2006-0112 dated May 15, 2006. This AD was amended to Revision 1 in order to recognize that Airbus SB A320-32-1338 is an acceptable terminating action for the repetitive inspection requirements of this AD.

On September 24, 2009, Airbus issued SB A320-32-1309, Revision 02 to inform operators of A318/A319/A320 and A321 aircraft that Airbus had issued SB A320-32-1338, which, if accomplished, would cancel the repetitive inspections required by SB A320-32-1309 Revision 01. SB A320-32-1309, Revision 02 also reduced the interval between repeat inspections from 900 flight cycles to 425 flight cycles for aircraft that had not accomplished the requirements of SB A320-32-1338. EASA AD 2006-0112R1 recognized that Airbus SB A320-32-1338 was an acceptable terminating action for the repetitive inspection requirement of this AD. The FAA also endorsed this Alternate Means of Compliance (AMOC).

On February 10, 2011, Airbus published All Operators Telex (AOT) A320-32A1390 to update operators of A318/A319/A320 and A321 aircraft on the recent cases of MLG door actuator failures. The AOT also recommends that the operators perform a weekly check of specific Centralized Fault Display System (CFDS) messages and conduct repetitive door opening inspections in order to better detect actuators that could be starting to fail.

On April 18, 2011, EASA published AD 2011-0069. This new AD, which supersedes EASA AD 2006-0112R1, requires an amendment of the applicable Airplane Flight Manual (AFM), repetitive checks of specific Centralized Fault Display System (CFDS) messages, repetitive inspections of the opening sequence of the MLG door actuator and, depending on findings, corrective action(s). According to the AD, after in-service introduction of the new MLG door actuator, P/N 114122012, several operators reported failures of internal parts of the MLG door

actuator. Investigations confirmed that these failures could result in slow extension of the actuator rod, delaying the MLG Door operation, or possibly stopping just before the end of the stroke, preventing the door to reach the fully open position. The AD specifies that the incorporation of the door actuator having part number 114122012 was no longer considered a terminating action for this new AD.

Checklist and Procedural Changes

Following the incident, United Airlines initiated a review and revision of the Landing Gear Irregular Procedures contained in the A319/A320 Flight Manual. The Landing Gear Unsafe Indication After Extension procedure was deleted from the manual and the Landing Gear Gravity Extension procedure was modified to eliminate the circular reference.

The final step in the Landing Gear Gravity Extension procedure was changed to reference the "appropriate landing gear irregular procedure". The previously named Landing Gear - Partial Gear or Gear Up Landing procedure was reworked into two different checklists. The Landing Gear - Nose Gear Unsafe, applicable when the nose gear failed to extend or lock down; and the Landing Gear - Partial Main Gear Or Main Gear Up Landing, applicable when one or both main gear failed to extend or lock down.

Following the incident, Airbus initiated a study which resulted in the issuance of an Operations Engineering Bulletin (OEB) that modified the "L/G GEAR NOT DOWNLOCKED" ECAM warning procedure. The modification was scheduled to be included in the next update of the Flight Warning Computer.

History of Flight

Landing	Landing gear not configured Sys/Comp malf/fail (non-power) (Defining event)
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Pilot Information

Certificate:	Airline Transport; Commercial; Flight Engineer	Age:	41, Male
Airplane Rating(s):	Multi-engine Land; Single-engine Land	Seat Occupied:	Left
Other Aircraft Rating(s):	None	Restraint Used:	Seatbelt, Shoulder harness
Instrument Rating(s):	Airplane	Second Pilot Present:	Yes
Instructor Rating(s):		Toxicology Performed:	No
Medical Certification:	Class 1 Unknown	Last Medical Exam:	10/23/2009
Occupational Pilot:	Yes	Last Flight Review or Equivalent:	08/01/2009
Flight Time:	14000 hours (Total, all aircraft), 915 hours (Total, this make and model), 8000 hours (Pilot In Command, all aircraft), 250 hours (Last 90 days, all aircraft), 82 hours (Last 30 days, all aircraft), 3 hours (Last 24 hours, all aircraft)		

Co-Pilot Information

Certificate:	Airline Transport; Commercial; Flight Engineer	Age:	46, Male
Airplane Rating(s):	Multi-engine Land; Single-engine Land	Seat Occupied:	Right
Other Aircraft Rating(s):	None	Restraint Used:	Seatbelt, Shoulder harness
Instrument Rating(s):	Airplane	Second Pilot Present:	Yes
Instructor Rating(s):	None	Toxicology Performed:	No
Medical Certification:	Class 1 Unknown	Last Medical Exam:	01/26/2009
Occupational Pilot:	Yes	Last Flight Review or Equivalent:	10/01/2009
Flight Time:	15000 hours (Total, all aircraft), 240 hours (Total, this make and model), 220 hours (Last 90 days, all aircraft), 73 hours (Last 30 days, all aircraft), 3 hours (Last 24 hours, all aircraft)		

Aircraft and Owner/Operator Information

Aircraft Manufacturer:	AIRBUS INDUSTRIE	Registration:	N816UA
Model/Series:	A319-131	Aircraft Category:	Airplane
Year of Manufacture:		Amateur Built:	No
Airworthiness Certificate:	Transport	Serial Number:	0871
Landing Gear Type:	Retractable - Tricycle	Seats:	128
Date/Type of Last Inspection:	01/09/2010, Continuous Airworthiness	Certified Max Gross Wt.:	166400 lbs
Time Since Last Inspection:		Engines:	2 Turbo Jet
Airframe Total Time:	36679 Hours	Engine Manufacturer:	IAE
ELT:	Installed, not activated	Engine Model/Series:	V2500SERIES
Registered Owner:	UNITED AIR LINES INC	Rated Power:	25000 lbs
Operator:	UNITED AIR LINES INC	Air Carrier Operating Certificate:	Flag carrier (121)
Operator Does Business As:		Operator Designator Code:	UALA

Meteorological Information and Flight Plan

Conditions at Accident Site:	Visual Conditions	Condition of Light:	Day
Observation Facility, Elevation:	KEWR, 18 ft msl	Observation Time:	1251 UTC
Distance from Accident Site:	1 Nautical Miles	Direction from Accident Site:	165°
Lowest Cloud Condition:	Clear	Temperature/Dew Point:	-9° C / -18° C
Lowest Ceiling:	None	Visibility	10 Miles
Wind Speed/Gusts, Direction:	7 knots, 340°	Visibility (RVR):	
Altimeter Setting:	30.28 inches Hg	Visibility (RVV):	
Precipitation and Obscuration:			
Departure Point:	Chicago, IL (KORD)	Type of Flight Plan Filed:	IFR
Destination:	Newark, NJ (KEWR)	Type of Clearance:	IFR
Departure Time:	0800 CST	Type of Airspace:	

Airport Information

Airport:	Newark (KEWR)	Runway Surface Type:	Concrete
Airport Elevation:	0 ft	Runway Surface Condition:	Dry
Runway Used:	04L	IFR Approach:	ILS; Visual
Runway Length/Width:	11000 ft / 150 ft	VFR Approach/Landing:	Straight-in

Wreckage and Impact Information

Crew Injuries:	5 None	Aircraft Damage:	Minor
Passenger Injuries:	3 Minor, 45 None	Aircraft Fire:	None
Ground Injuries:	N/A	Aircraft Explosion:	None
Total Injuries:	3 Minor, 50 None	Latitude, Longitude:	

Administrative Information

Investigator In Charge (IIC):	William R English	Adopted Date:	06/27/2011
Additional Participating Persons:			
Publish Date:	06/27/2011		
Investigation Docket:	http://dms.nts.gov/pubdms/search/dockList.cfm?mKey=75258		

The National Transportation Safety Board (NTSB), established in 1967, is an independent federal agency mandated by Congress through the Independent Safety Board Act of 1974 to investigate transportation accidents, determine the probable causes of the accidents, issue safety recommendations, study transportation safety issues, and evaluate the safety effectiveness of government agencies involved in transportation. The NTSB makes public its actions and decisions through accident reports, safety studies, special investigation reports, safety recommendations, and statistical reviews.

The Independent Safety Board Act, as codified at 49 U.S.C. Section 1154(b), precludes the admission into evidence or use of any part of an NTSB report related to an incident or accident in a civil action for damages resulting from a matter mentioned in the report.