

SERIOUS INCIDENT

Aircraft Type and Registration:	Jetstream 4100, G-MAJW	
No & Type of Engines:	2 Garrett AiResearch TPE331-14GR-807H turboprop engines	
Year of Manufacture:	1993 (Serial no: 41015)	
Date & Time (UTC):	27 February 2018 at 1200 hrs	
Location:	Aberdeen Airport	
Type of Flight:	Commercial Air Transport (Passenger)	
Persons on Board:	Crew - 3	Passengers - 18
Injuries:	Crew - None	Passengers - None
Nature of Damage:	Overwing emergency exits during evacuation	
Commander's Licence:	Airline Transport Pilot's Licence	
Commander's Age:	37 years	
Commander's Flying Experience:	3,830 hours (of which 2,325 were on type) Last 90 days - 183 hours Last 28 days - 66 hours	
Information Source:	Aircraft Accident Report Form submitted by the pilot	

Synopsis

On the approach to Sumburgh Airport, the primary and standby landing gear status indicators showed that the nose landing gear was not extended and downlocked. The crew aborted the approach, elected to return to Aberdeen and after unsuccessfully attempting to resolve the issue, declared a MAYDAY. The aircraft landed safely at 1235 hrs and the occupants evacuated via the overwing exits after the aircraft stopped on the runway.

A subsequent ground inspection of the aircraft confirmed that the nose landing gear was 'down and locked' but the primary indication wiring harness had failed and the standby indication microswitch was out of position. Safety actions have been taken by the manufacturer and the operator to improve the reliability of the system and the clarity of the Emergency and Abnormal Checklists.

History of the flight

After an uneventful charter flight from Aberdeen Airport, the aircraft was on approach to Runway 09 at Sumburgh Airport at 1038 hrs when the crew selected the landing gear down. The primary landing gear status indicator (Figure 1) showed the nose landing gear (NLG) was not extended and downlocked (left and right-hand main landing gear (MLG) indications GREEN, NLG indication RED). The standby indicator showed GREEN for the MLG but no light for the NLG and shortly afterwards the selector lever indicator illuminated

RED. The crew aborted the approach to troubleshoot the issue using the Emergency and Abnormal Checklist Card 48 '*Landing Gear Not Locked Down*'. The crew verified there was no loss of electrical or hydraulic power, reset the landing gear control circuit-breakers and recycled the landing gear (retraction followed by re-extension). When the landing gear was selected UP, both indication systems displayed all the landing gears 'up and locked'. The next checklist action was to extend the landing gear using the emergency system, after which an in-flight retraction would have no longer been possible. The crew declared a PAN and elected to return to Aberdeen Airport at 1052 hrs with the landing gear retracted.

The aircraft entered the hold above Aberdeen Airport at 1126 hrs and the flight crew completed the actions on Card 48. They used the emergency extension system and applied small manoeuvres at the normal and maximum permissible speeds to release the NLG, all of which failed to achieve a GREEN indication. At 1138 hrs the crew declared a MAYDAY and prepared for landing, following Card 49 '*Nose Landing Gear Not Locked Down*'.

The crew flew two passes along the runway, one at 3,000 ft, a second at 1,500 ft and visual confirmation was given that the NLG was down but no assessment of the downlock status could be made. The flight crew evaluated the risk of a NLG collapse on landing as extremely likely, so decided they would evacuate the passengers via the overwing exits after landing and briefed the cabin crew, passengers and ATC accordingly.

The aircraft landed at 1235 hrs with the NLG remaining in the down position and stopped on the runway. Card 96 '*Emergency Evacuation*' states the evacuation command should be issued once the propellers have stopped turning but, in this instance, the first command for evacuation was issued by the cabin crew once the aircraft had stopped. They immediately noticed the propellers were still turning and told the passengers to wait until the propellers had stopped before opening the overwing exits. Once the propellers had stopped, subsequent commands for evacuation were issued by both the flight crew and cabin crew. All the passengers and crew then evacuated as planned, with no injuries and were transferred to the terminal by bus.

Aircraft information

The Jetstream 41 has a tricycle landing gear with two wheels on each landing gear leg which retract forwards into either the fuselage (NLG) or the engine nacelle (MLG). The hydraulically-operated extension and retraction system is commanded by a selector lever in the cockpit. It uses 2,000 psi hydraulic pressure to maintain the landing gear in the extended or retracted position with secondary mechanical downlocks and uplocks on each leg. There is an emergency extension system if hydraulic power is lost.

Landing gear position is primarily indicated by illuminated captions on the landing gear selector-panel by RED or GREEN captions (Figure 1). A GREEN caption denotes the associated landing gear is 'down and locked' whereas a RED caption denotes either the gear is unlocked or in transit. When the landing gear is retracted and locked, no caption is lit. Microswitches on the downlocks and uplocks are used to control the cockpit display indicators and there are two on each downlock and one on each uplock. On the right-hand

side console are three standby indicators which illuminate GREEN when the associated gear is 'down and locked'. The selector lever will illuminate RED when the landing gear transit time, from unlock to lock, exceeds 15 seconds.

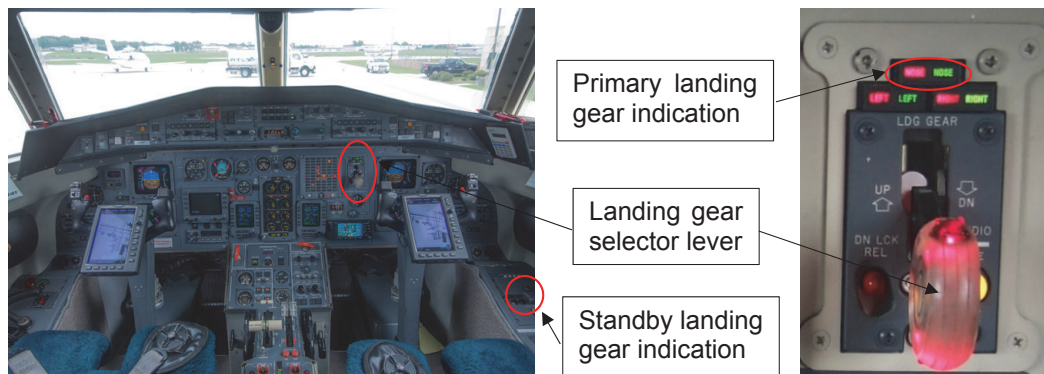


Figure 1

Location of the landing gear indicators

Aircraft examination

Following the incident, the aircraft structure was inspected, and the overwing emergency exits were found damaged from ground contact during the evacuation. A systems check identified a fault with the primary NLG downlock microswitch harness and the NLG standby microswitch was found out of position.

Downlock microswitches

Primary downlock microswitch

The NLG primary downlock microswitch and its associated wiring harness were removed from the aircraft for further examination (Figure 2). No visual defects were identified but movement could be felt between the wiring harness and the microswitch which was due to damaged and broken wires in the harness.



Figure 2

Primary down lock microswitch

The harness had been fitted to the aircraft during scheduled maintenance of the downlock assembly on 6 May 2016 and the aircraft had since completed 2,291 flight cycles. The harness was to the latest modification standard, the protective boots and sheathing were in good condition and with adequate moisture-inhibiting compound present. In response to this incident, the operator has introduced a 600 flight hours repetitive inspection of both indication systems and during the initial fleet-wide inspection, no further harness failures were found.

Standby downlock microswitch

The NLG standby microswitch was in a serviceable condition but there was a gap between the microswitch plunger and the downlock pin resulting in the switch not operating when the landing gear was 'down and locked' (Figure 3). This condition could have resulted from being rigged incorrectly at the last maintenance interval, the microswitch support bracket having moved in-service, or a combination of both.

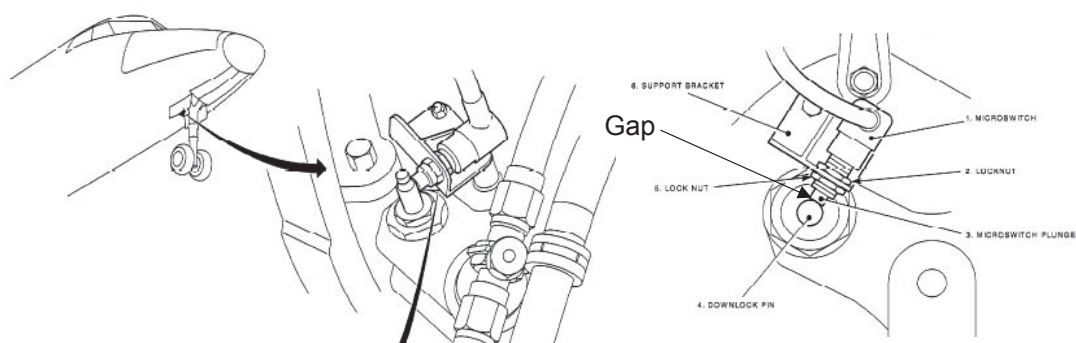


Figure 3

Standby downlock microswitch

In response to this incident, the operator has performed a fleet-wide 'one-off' inspection of the position of the standby microswitches. Of the 12 aircraft inspected; five were correctly positioned, five were marginally out of position but with no effect on operation and two were only just engaged with the downlock pin.

A further outcome of this inspection was to highlight an issue with the task '*Adjust the NLG downlock microswitch*' in the Aircraft Maintenance Manual (AMM). The task states it is '*applicable to the normal [primary] and the standby microswitches. The adjustment of one microswitch is given*'. However, this task is actually specific to the primary system as it only refers to the selector panel indicators, whereas the standby microswitch controls the standby panel indicators. The manufacturer has issued a Technical Operation Response to clarify the AMM task, on which indicators are used during the adjustment of the standby microswitch, and is revising the AMM to reflect this clarification.

Emergency and Abnormal Checklists

Following the indications that the NLG was not 'down and locked' during the approach to Sumburgh Airport, the flight crew referred to the Emergency and Abnormal Checklists (E&AC) to troubleshoot the problem. The E&AC cards are a series of checklists produced by the manufacturer to enable the flight crew to efficiently and safely manage a wide range of emergencies and abnormal events. Operators may customise the checklists to suit their own standard operating procedures and this operator had done so.

In an emergency or abnormal event, the flight crew select from the contents page the most appropriate card. Some cards share a very similar title but fulfil different functions. For instance, Card 48 is for aircraft system-level troubleshooting whereas Card 49 (and 50 & 51) is the checklist applicable to landing. Figure 4 shows an extract from the contents page for the operator's E&AC cards related to the landing gear. It is noted that Card 50 '*One Main Landing Gear Not Locked Down, Nose Gear Up or Down*' was not included.

HYDRAULICS		
Emergency extension of landing gear	-47	
Landing gear not locked down	-48	
Unable to raise Landing Gear – Selector Lever Immovable	-48A	
Landing Gear Selector Lever Up – Landing Gear Not Locked Up	-48B	
Nose landing gear not locked down	-49	
Both main landing gear not locked down, nose landing gear up or down	-51	
Emergency extension of flaps	-52	
Hydraulic system low pressure	-53	_LO PRESS
Hydraulic pump low pressure	-54/1	
Hydraulic fluid high temperature	-54/2	HI TEMP
Reservoir contents in amber sector	-55	
Emergency reservoir low quantity	-56	EMER QTY
Low brake pressure	-56	LO MAIN / EMERG
Loss of normal braking	-57	
Anti-skid fault	-57	A-SKID

Figure 4

Operator's list of Emergency and Abnormal Checklists – Landing gear

During the investigation there were two cases identified where sections of one card were duplicated on another but with some information changed or missing. Mid-way through Card 48 the emergency extension procedure is reproduced, however, there are several notes missing from Card 48 which are included on Card 47. These are:

'WARNING: To prevent the loss of hydraulic fluid, do not operate the emergency hand pump in flight with the emergency selector set to NORMAL.'

CAUTION: Nosewheel steering may not be available after the landing gear has been extended by the emergency system.

NOTE 3: The flaps may be extended before the landing gear, but flap extension will stop if the [EMERG QTY] caption comes on.

NOTE 4: The emergency system can still be used to extend the landing gear after the [EMERG QTY] caption comes on.'

At the top of Card 49 it states that:

'NOTE: This procedure must only be applied if the nose gear green light is not illuminated after completing Card 47: EMERGENCY EXTENSION OF LANDING GEAR.'

In this incident, the crew had completed an emergency extension whilst on Card 48 but they had sufficient time prior to landing to study all the related E&AC cards and were therefore aware of the additional notes on Card 47.

The second example of duplication is on Cards 49 'Nose Landing Gear Not Locked Down' and 96 'Emergency Evacuation'. In this case the actions to shut off the engines are required 'On touchdown' when following Card 49 but after aircraft stop on Card 96. Card 49 states that the fire extinguishers are to be used once the aircraft has stopped and then to proceed to Card 96. However, Card 96 details the evacuation procedure before finally stating fire extinguishers to be used, if required.

A report by the operator concluded that, had there been time pressure or different circumstances, errors or confusion may have occurred due to duplication and the format of the E&AC Cards.

Analysis

Downlocks

It is probable that the failure of the primary downlock harness was due to vibration as the environmental protection was in good condition. To verify the condition of the fleet, the operator has inspected all the other harnesses fitted to their aircraft and no other failures were found, so they are considering it an isolated event.

The gap condition between the standby microswitch and the downlock pin could have resulted from incorrect rigging, movement of the support bracket, or a combination of both. The flight crew stated that the standby indication system was working prior to the incident flight, which they had verified in accordance with their standard operating procedures, and the standby system is further checked by a maintenance programme

task every 300 flight hours. The indicator system is designed that only one system needs to confirm the landing gear is 'down and locked'. However, if a crew is unaware the standby system is not working, it becomes a 'dormant' failure, and should the primary system subsequently fail, the crew will be unable to determine whether it is an indication system fault or a landing gear fault.

The investigation carried out by the operator highlighted the potential for misunderstanding the AMM procedure for rigging the standby downlock microswitch, however it was concluded that it was unlikely to have caused the microswitch to be out of position.

Emergency and abnormal checklists

A comprehensive report by the operator concluded that, had there been time pressure or different circumstances, errors or confusion may have occurred due to duplication, formatting and titles of the E&AC Cards. These findings did not detrimentally influence this specific incident as the crew had sufficient time to review all the cards and construct their own landing plan, but it increased their workload. The manufacturer will review all the E&AC cards to resolve any variations in duplicated procedures and to review all the card titles to ensure they accurately and efficiently reflect the intention of the card.

Emergency evacuation

During their initial troubleshooting the crew had verified that the electrical and hydraulic systems were functioning normally and had GREEN indications for the MLG. By observation made during the flypasts, they knew that the NLG was extended and concluded there was a NLG downlock fault. They did not consider an indication fault due to the perceived improbability of a double failure of the indication system. The crew stated they used a "Threat and Error Management" approach to evaluate different landing scenarios with either a NLG collapse during landing or after the aircraft had come to a stop. To minimise the risk of passenger injury they briefed the passengers to evacuate the aircraft only using the overwing exits and not to use the forward main exit with integral steps. However, they did mention the rear exit. The crew also considered whether a NLG ground downlock pin could be inserted prior to a rapid disembarkation but they considered the risk of injury too high if the NLG were to collapse and decided to evacuate at the earliest opportunity.

Conclusion

On approach to Sumburgh Airport the primary indication system for the NLG did not indicate 'down and locked' due to a failure between the microswitch and the wiring harness. The failure of the standby indication system to illuminate was because the microswitch was out of position relative to the downlock pin.

Based upon the information from two indication systems that the NLG was not 'down and locked', the crew reviewed possible landing scenarios and planned their actions based upon a landing with a NLG collapse. This did not happen; the crew followed their plan and successfully evacuated all passengers and crew through the overwing exits with no injuries.

Safety actions

The manufacturer has taken a Safety Action to amend the AMM and a further Safety Action to thoroughly review all Emergency and Abnormal Checklist cards to ensure that the correct card is actioned efficiently without confusion.

- Revision to AMM to clarify NLG down lock microswitch rigging procedure.
- Review the Emergency and Abnormal Checklists to improve clarity and efficiency of application.

Three Safety Actions have been taken by the operator to improve the reliability of the landing gear indication systems and to implement the latest revision of the Emergency and Abnormal Checklist cards.

- 'One-off' inspection - Nose landing gear standby micro switch check.
- 'One-off' inspection - NLG down lock and primary and standby microswitch inspection.
- Repeat inspection every 600 flight hours - Landing gear indication system check.
- Update all Emergency and Abnormal Checklists in accordance with manufacturers latest revision.