Fokker F27 MK 050, PH-KVK, 8 December 1996

AAIB Bulletin No: 8/97 Ref: EW/C96/12/1 Category: 1.1

Aircraft Type and Registration:	Fokker F27 MK 050, PH-KVK
No & Type of Engines:	2 Pratt & Whitney PW125B turboprop engines
Year of Manufacture:	1991
Date & Time (UTC):	8 December 1996 at 1254 hrs
Location:	London Heathrow Airport
Type of Flight:	Public Transport
Persons on Board:	Crew - 4 - Passengers - 41
Injuries:	Crew - None - Passengers - 3 Minor
Nature of Damage:	Substantial to left rear fuselage, left propeller and left wing tip
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	30 years
Commander's Flying Experience:	2,600 hours (of which 370 were on type)
	Last 90 days - 130 hours
	Last 28 days - 40 hours
Information Source:	AAIB Field Investigation

The aircraft was on a scheduled service from Rotterdam to LondonHeathrow with 4 crew and 41 passengers on board. As the aircraftapproached the London Terminal Manoeuvring Area (TMA) the crewwere instructed to hold at the Lambourne (LAM) VOR. After threeholds the aircraft was radar vectored for an ILS approach to Runway27 left. The landing gear was selected down normally butthe crew noticed that the left main landing gear showed an unsafeindication. The commander, who was the handling pilot, therefore,decided to carry out a go-around in order to investigate the problem. Before initiating the go-around manoeuvre, however, he askedthe first officer to consult the 'MAIN GEAR UNSAFEAFTER DOWN SELECTION' check list to see whether he shouldraise the gear. The first item on the checklist was to recyclethe gear The gear was therefore raised during the go-around asthe first part of that procedure.

After the go-around, which was carried out at 1153 hrs,the crew were instructed by ATC to take up a heading of 120°Mand climb to 3,000 feet. ATC then asked for the reason forthe go-around and whether the crew wished to make a further approach. The crew needed time for their investigation, so ATC suggestedthat the aircraft should hold at the Epsom NDB. The aircraftentered the hold at 1201 hrs and the crew returned to the'MAIN GEAR UNSAFE AFTER DOWN SELECTION' checklist. They re-selected the gear down, completing the recycle. This,however, was also unsuccessful. The first officer then left theflight deck to check visually if the left main gear was down andlocked by looking for alignment of painted red lines on the landinggear strut. His inspection showed that the gear was not in asafe condition (Figure 1).

On his return to the flight deck the crew initiated the 'ALTERNATEDOWN PROCEDURE'. As this was also unsuccessful the commander,in accordance with the checklist, requested clearance from ATCto carry out a level '2g' (60° bank) turn at 170 kt. This manoeuvre, however, did not affect the left main gear unsafeindication.

At this stage the crew were now committed to an emergency landing. At 1212 hrs they transmitted to ATC that "WEHAVE THE INTENTION TO MAKE AN EMERGENCY LANDING AT HEATHROW....ANDWE NEED APPROXIMATELY 15 MINUTES FOR PREPARATION...THE LANDINGGEAR SYSTEM IS DOWN BUT NOT LOCKED SO THERE IS A HIGH RISK OFTHE GEAR COLLAPSING AFTER TOUCHDOWN". The airportemergency services were alerted and brought to an 'AIRCRAFTACCIDENT IMMINENT' status.

At 1222 hrs the Heathrow Director informed the crew thatthe surface wind was now favouring a landing on the easterly runwaysand that Runway 09R would be used. The weather was passed tothe crew as visibility 8 km, scattered cloud at 400 feet, overcastcloud at 600 feet and a surface wind of 140°/4 to 7 kt.

In preparation for the landing the crew actioned the 'ONEMAIN GEAR UP or UNSAFE' checklist. At 1232 hrs ATCasked if the crew were ready for the approach. The crew repliedthat "THE CABIN IS STILL BEING PREPARED SO WENEED AT LEAST ONE OR TWO MORE HOLDS". AT 1238hrs, having updated ATC on the number of persons on board thecrew declared a 'MAYDAY' and stated that "WEHAVE 600 KG OF FUEL LEFT WHICH GIVES US A LOW FUEL EMERGENCY UPONLANDING AND WE EXPECT A COLLAPSE OF THE LEFT-HAND GEAR UPON TOUCHDOWN".

At 1248 hrs, after a very comprehensive preparation of theaircraft and cabin, the aircraft, having been radar vectored,intercepted the ILS to Runway 09R. The aircraft's trackhad taken it clear, to the south-west, of the built-up areas ofthe outskirts of London. The aircraft however had not presentedany danger to areas beneath its flight path as the emergency situationwould only develop on landing.

The aircraft's touchdown was normal at 1253 hrs right mainwheel first. About 5 seconds after all the landing gearwere in ground contact the left main landing gear collapsed andthe aircraft left wing tip, left propeller and the rear left portionof the fuselage contacted the runway. The aircraft veered tothe left coming to rest on the hard surface clear of the runwayin Block 81.

A full aircraft evacuation was then carried out with approximatelyhalf the passengers leaving the aircraft via the front left doorwhilst the remainder exited via the half open rear left door. The commander was the last to leave the aircraft via the rearleft door.

The front left door, which is hinged at its lower edge and incorporatesseveral steps, opened normally but the door adopted a horizontalattitude because of the fuselage's close proximity to the

ground. The rear left door opened normally but its lower corner contactedthe ground with the door only 90° open. Although the widthavailable for evacuation was reduced the passengers exited theaircraft without difficulty.

Flight Recorders

The Flight Data Recorder (FDR) and Cockpit Voice Recorder (CVR)were removed from the aircraft and replayed at the AAIB. Therecorded data on the FDR showed that the aircraft had made theinitial go around at an altitude of 1,040 feet agl.

The aircraft then levelled at 3,000 feet agl and joinedthe holding pattern over Epsom. During the second hold, whilstcarrying out the unsuccessful attempt to lock down the left maingear, the aircraft had made a tight 360 degree turn whichresulted in a recorded maximum vertical acceleration of 1.95g.The Epsom hold was then re-established and flown a further seventimes. At 1253 hrs the aircraft touched down at 92 ktwith flap 35 selected rolled 0.5 degrees to the right. Theright main gear touched first. Five seconds later the FDR recordedthat all three oleos were on the ground.

Ten seconds after the initial touchdown, at a speed of 67 kt,a sharp roll of 13 degrees to the left and a large verticalacceleration were recorded as the left main gear collapsed. Theaircraft began to slew to the left, finally coming to rest, aftera further 12 seconds, on a heading of 017°M. During thistime the left hand propeller came into contact with the runwayand slowed from 80% RPM to 63% RPM. The sound of thepropeller blade tips striking the ground was audible on the CVRrecording.

Once the aircraft came to rest the non-handling pilot pulled theengine 1 fire handle whilst the Captain set the parking brake.The Captain then called for the on-ground emergency checklistand the First Officer pulled the No 2 engine fire handleand set the fuel levers to off before the CVR and FDR recordingsterminated.

Engineering Aspects

The aircraft came to a halt on a taxiway having slewed throughabout 90_ to the left. It rested on its nose and right main landinggears, the fuselage underside and the left wing tip. The leftmain landing gear had partially retracted into its well. Forrecovery the aircraft's left wing was lifted using air bags andthen supported on a jack. The left gear began to extend as thewing was lifted and as it emerged from the wheel well it couldbe seen that the platform which forms one half of the over-centringstop in the lock-link (Figure 2) was not fully securedand was slightly displaced. The platform was aligned and tapedin place. As the wing was lifted further and the gear reachedfull extension the lock-link went over-centre and the gear lockeddown.

One of the two bolts used to secure the platform was found tobe missing and the other one was loose. At the position of themissing bolt contact marks showed that a bolt had been presentat one time. The head of the remaining bolt was drilled for wirelocking but no wire was present. The wheel well was searchedfor the missing bolt. This was not found but a washer was foundwhich matched the washer on the remaining bolt for type, sizeand paint colour. The platform was free to rotate about the remainingbolt and some damage marks showed that it had fouled an adjacentstepped surface of the lock-link and this had prevented the lock-linkfrom achieving the over-centred condition. When this conditionwas replicated the lock-link was seen to be in the position describedby the crew in which the ground lock pin holes in the two sectionsof the lock-link were misaligned by one diameter. No other defectswere apparent in the left main landing gear, the

extension jackand the lock-link over-centring spring were tested separately,and the investigation concentrated on the retention and lockingof the platform.

On manufacture, when the initial assembly of the lock-link hasbeen completed and after locking wire has been fitted, the linkis coated with a primer paint and a cosmetic silver paint. Evidencefor the presence of locking wire should, therefore, be visiblein the paint coating on the bolt head as well as in contact markson its metallic surface (it is cadmium plated). The head of theremaining bolt was examined closely and at one of the three lockingwire holes there was damage on the edge of the hole at each endwhich appeared consistent with the use of locking wire. The othertwo holes were clear of any such contact damage. Microscopicexamination of the head of the recovered bolt revealed no evidencethat it had been untightened at any time, in fact the conditionof the painted surfaces indicated that it had not. (Under thepaint there were some contact marks on the hexagon faces consistentwith spanner or socket application in the tightening direction.) The paint on the bolt head had suffered some in service damageor erosion and there were two small impact marks on the top edgesof the head almost diametrically opposite one another. It couldnot be determined what the cause, or effect, of these impactsmight have been.

Manufacturing and Overhaul Documentation

The landing gear manufacturer's assembly drawing for the locklink did not show locking wire drawn at the location of the twobolts which secure the platform and a drawing note (specifyingwire locking) which had been applied to other locations whichrequired wire locking was not applied to the bolts. The boltswhich were shown on the drawing (and supplied in the kit of partsfor assembly) were specified as NAS 1303-15H. On this bolt, holesare provided in the hexagon head for wire locking. The assemblydrawing referred to a manufacturing standards document which itselfreferred to a company process specification which defined standardpractices for component assembly. This document contained thestatement:-

"Where a drawing does not call out this specification togetherwith an item reference, the appropriate instructions in paragraph4 shall apply, in the absence of specific instructions to thecontrary."

Paragraph 4 contained the process specifications including wirelocking.

The lock-link was assembled in accordance with a document containinga list of numbered operations and inspections for the numberedoperations were recorded on separate sheets. The subject lock-linkwas assembled as one of a batch of four, all being recorded onone set of paperwork. Three other batches of four were assembledat around the same time by the same team and, for the investigation,these were considered to form one batch and an attempt was madeto trace these. In the instruction which included the final torquetightening of the platform bolts there was a note giving the processspecification for the torquing of the bolts but no instructionor note on the locking of the bolts. Nevertheless, staff at thelanding gear manufacturer stated that it was standard practiceto apply wire locking to all nuts or bolts to which it could beapplied and the physical evidence from the remaining bolt wasthat wire had been present in one of the holes in the bolt atsome time. After the incident the assembly drawing, as the masterreference document for the build of the lock-link (though it wasonly used within the company), was re-issued with wire lockingshown and appropriate notes applied.

The landing gear manufacturer also found that the Component MaintenanceManual (CMM) for the lock-link (Chap 32-10-53 Rev 10) did notcontain an instruction to wire lock the platform bolts even

thoughthere were specific instructions to this effect for other fasteners. The CMM is the document that would be used by any agency otherthan the manufacturer that might overhaul a Fokker 50 landinggear or one of its component parts. This information did notaffect the investigation of the collapse of the gear on PH-KVKas that gear had not been overhauled but the CMM, which was inthe process of being re-issued while the investigation was inprogress, was amended to include an instruction for the wire lockingof the platform bolts.

The landing gear manufacturer reported that the company had recordedsome cases of problems with the quality of wire locking between1991 and 1995. The outcome of an investigation which was carriedout was to improve the training of fitters in the required proceduresand standards.

Maintenance History

The aircraft's records did not show that the landing gear on PH-KVKhad been changed or overhauled since the aircraft had been builtand so the gear had been last assembled during its original buildby the manufacturer. There were two anomalies between the leftlanding gear component serial numbers recorded in the recordsand those found on the aircraft but these were single digit differencesand were probably transposition errors. There was no discrepancybetween the lock-link serial number as found and as recorded.

Detailed inspection of the landing gears is required in the scheduled"B" Checks at 650 hour intervals:-

"1.11 Examine the MLG, and make sure that:

- All the bolts, the nuts and the attachment points are correctlyinstalled.

- All the split-pins, the lockwires and the lock plates are correctlyinstalled and intact."

The last "B" Check had been conducted on 18 October1996 at 9,552 airframe hours and 9,443 cycles.

A search of the records of unscheduled maintenance or rectificationrevealed no work directly affecting the platform and the storesrecord showed that this component had never been replaced. Thedownlock microswitch is contained within an open housing or bracketthe front face of which is immediately behind the heads of theplatform bolts. It was considered that, if work was being carriedout on the microswitch, it was possible that the platform boltscould be mistaken for the front retention bolts of the bracket. In fact, the front of the bracket is secured by two countersunkscrews transversely installed but its rear flange is held by twobolts of the same size as the platform bolts which are not wirelocked. It is not necessary to remove the bracket from the lock-linkin order to remove or change the microswitch as the microswitchcan be extracted with the bracket remaining in place. The lastaction recorded affecting the microswitch arose from the rectificationof an indication fault in the right main gear on 13 February 1994. During rectification the left microswitch system was cleanedand adjusted as well as the right. However, adjustment of themicroswitch operation is made to the striker bolt, not the microswitchitself, and should not have involved any disturbance of the bracket,its attachment bolts and screws or the platform bolts and therewould seem to be little opportunity for their mistaken disturbancein that operation.

Safety Actions

On 9 December, the day following the accident, Fokker Servicesissued an All Operators Message (AOM) (AOF50.005) reporting theoccurrence and recommending that an inspection for the presenceof correct wire locking should be considered. As a result ofthe AOM a report was returned of a broken locking wire on anotheraircraft, with one section of the wire completely missing, andon 13 December the AAIB and the Accidents and Incidents InvestigationBureau (AIIB) of the Netherlands Aviation Safety Board issuedrecommendations to the Netherlands Airworthiness Authority (RLD)that Fokker's recommendation be strengthened, and that they requireoperators to carry out inspections. The AAIB recommendation readas follows:-

Recommendation 96/83: It was recommended:-

That the Netherlands regulatory authorities should require operatorsof the Fokker 50 to inspect the retention bolts of the maingeardown lock platforms to confirm the presence and condition of thelocking wire between the two bolt heads, report back and repairany deficiency found, after advice from the manufacturer.

On 18 December, in an All Operators Message (006), Fokkerannounced the issue of Service Bulletin SB F50-32-033 which wasmandated by RLD (Airworthiness Directive BLA1996-146(A)) and on20 December the RLD raised an Action Record Sheet (ARS27-04-07)which required Fokker Services "to review the downlock platformretention design and provide changes to comply with JAR 25.607/1309".

In the feedback from operators, out of the existing 210 aircraftinformation was obtained on 138 plus information on 11 spare lock-linkunits. Two additional anomalies were reported; in one case thelock wire was wrongly applied and in the other (overhauled) casethe wiring was missing. Included in these reports were 10 otherunits from the manufacturing batch containing the subject lock-link. (Amongst the lock-links not traced some had been overhauled andtherefore their original condition was lost.) No anomalies werereported in these units.

The actions of the crew, in following the emergency procedures,left the normal landing gear selector and the "ALTERNATE"gear selector in the "DOWN" position. The "ALTERNATE"selector operates a cable system which, in the "DOWN"position, opens a dump valve which vents hydraulic pump pressureand mechanically releases the uplocks of the main gears and thenose gear front doors. In this condition, with the normal gearselector also selected "DOWN", hydraulic pressure onboth sides of the actuator is vented so that there is no hydraulicresistance to the leg descending under its own weight and aerodynamicloads. None of these functions were relevant to the circumstancesin this accident and once the aircraft had touched down the hydraulicsystem offered no resistance to the leg retracting, allowing thewingtip, fuselage and left propeller to contact the ground. Inview of this a further recommendation was made:-

Recommendation 97/25 Revision 1:-

(As revised following discussions with the Dutch AIIB)

It is recommended that Fokker Services consider, in the lightof this accident and considering the variety of emergency situationswhich may arise, including leakage in the hydraulic system, whetherchanges to the landing gear emergency extension proceduresare possible in order either,

1) to enable flight crews to decide when an "ALTERNATE DOWN"selection is appropriate

or

2) to return the landing gear hydraulic system finally to "NORMAL"operation with "DOWN" selected to pressurise the extensionside of the landing gear actuator and reduce the likelihood ofa landing gear retraction after landing.

Fokker Services should ensure that any changes are consistentwith the design philosophy of the system and the check list.

Discussion

The platform bolts are secured by two mechanisms; primarily bolttorque and secondarily wire locking. A number of different caseswere considered to explain the loss of bolt security and the absenceof the locking wire.:-

1) Incorrect assembly. (Bolt torque incorrect, locking wire omittedor incorrectly applied.)

2) Wire intentionally removed by mechanic, possibly during microswitchwork.

3) Wire broken accidentally during maintenance.

4) Wire broken by some damage in service.

5) Operating loads reduced bolt torque and were transferred tothe locking wire after the bolts had become loose and causingit to break.

Evidence was found that a tightening torque had been applied tothe remaining bolt and that locking wire had been present on thehead of the bolt though the evidence is not sufficient to showwhether the torque was correctly set or the wire locking correctlyperformed (Case 1).

The only work which the maintenance documentation for this arearecords, apart from inspection, lubrication and cleaning, is adjustmentof the microswitch. This is effected through an adjuster on thepivoting lever arm in the downlock assembly and there seems littlepotential for mistaken interference with the platform bolts (Case2).

The two small marks on the head of the remaining bolt shows thatthere had been an impact (or impacts) on the head but this evidenceis not sufficient to show what the cause or effect of this mighthave been and so, though Cases 3 and 4 are possible means by whichthe wire locking could have been lost, the evidence is insufficientto confirm either.

Close consideration of the platform and its retention bolts suggestedthat the bolts could be subjected to untightening loads in servicethough these proved difficult to assess (Case 5). Once the boltsstarted to turn these loads would be transmitted to the wire itselfand could cause it to fail. The Action Record Sheet raised bythe Netherlands airworthiness authorities initiated a review ofthe design of the downlock platform retention system.