ANSV AGENZIA NAZIONALE PER LA SICUREZZA DEL VOLO

# FINAL REPORT

**ACCIDENT**
**occurred to**
**FOKKER F27 MK50**
**registration marks SE-LEZ,**
**at Catania Airport,**
**April 30, 2016**

# INDEX

# OBJECTIVE OF THE SAFETY INVESTIGATION

The Agenzia nazionale per la sicurezza del volo (ANSV), instituted with legislative decree No 66 of 25 February 1999, is the Italian Civil Aviation Safety Investigation Authority (art. 4 of EU Regulation No 996/2010 of the European Parliament and of the Council of 20 October 2010). **It conducts, in an independent manner, safety investigations.**

Every accident or serious incident involving a civil aviation aircraft shall be subject of a safety investigation, by the combined limits foreseen by EU Regulation No 996/2010, paragraphs 1, 4 and 5 of art. 5.

The safety investigation is a process conducted by a safety investigation authority for the purpose of accident and incident prevention, which includes the gathering and analysis of information, the drawing of conclusions, including the determination of cause(s) and/or contributing factors and, when appropriate, the making of safety recommendations.

**The only objective of a safety investigation is the prevention of future accidents and incidents, without apportioning blame or liability (art. 1, paragraph 1, EU Regulation No 996/2010). Consequently, it is conducted in a separate and independent manner from investigations (such as those of Judicial Authority) finalized to apportion blame or liability.**

Safety investigations are conducted in conformity with Annex 13 of the Convention on International Civil Aviation, also known as Chicago Convention (signed on 7 December 1944, approved and made executive in Italy with legislative decree No 616 of 6 March 1948, ratified with law No 561 of 17 April 1956) and with EU Regulation No 996/2010.

Every safety investigation is concluded by a report written in a form appropriate to the type and seriousness of the accident or serious incident. The report shall contain, where appropriate, safety recommendations, which consist in a proposal made with the intention of preventing accident and incidents.

**A safety recommendation shall in no case create a presumption of blame or liability for an accident, serious incident or incident (art. 17, paragraph 3, EU Regulation No 996/2010).**

The report shall protect the anonymity of any individual involved in the accident or serious incident (art. 16, paragraph 2, EU Regulation No 996/2010).

This report has been translated and published by ANSV for the English-speaking concerned public. The intent was not to produce a factual translation and as accurate as the translation may be, **the original text in Italian is the work of reference.**

# GLOSSARY

**(A)**: Aeroplane.
**AAIB (UK)**: Air Accident Investigation Branch (UK).
**AD**: Airworthiness Directive.
**AMM**: Aircraft Maintenance Manual.
**ANSV**: Agenzia nazionale per la sicurezza del volo.
**AOC**: Air Operator Certificate.
**AOM**: Aircraft Operating Manual.
**APP**: Approach control office o Approach control or Approach control service.
**ATL**: Aircraft Technical Logbook.
**ATPL**: Airline Transport Pilot Licence.
**ATS**: Air Traffic Services.
**CAA**: Civil Aviation Authority.
**CAME**: Continuing Airworthiness Management Exposition.
**CAMO**: Continuing Airworthiness Management Organization.
**CMM**: Component Maintenance Manual.
**CRS**: Certificate of Release to Service.
**CS**: Certifying Staff.
**CVR**: Cockpit Voice Recorder.
**DSB**: Dutch Safety Board.
**EASA**: European Union Aviation Safety Agency.
**ENAC**: Ente nazionale per l'aviazione civile.
**FDR**: Flight Data Recorder.
**FMS**: Flight Management System.
**FT**: Foot (piede), (1 ft = 0,3048 mt)
**ICAO/OACI**: International Civil Aviation Organization, Organizzazione dell'aviazione civile internazionale.
**IFR**: Instrument Flight Rules.
**ILS**: Instrument Landing System.
**IR**: Instrument Rating.
**JC**: Job Card.
**KT**: Knot.
**ME**: Multi Engine.
**METAR**: Aviation routine weather report.
**MP**: Multi Pilot.
**MTOM**: Maximum Take Off Mass.
**NLG**: Nose Landing Gear.
**NM**: Nautical Miles.
**PF**: Pilot Flying.
**PIC**: Pilot in Command.
**P/N**: Part Number.
**PNF**: Pilot Not Flying.
**RWY**: Runway.
**SB**: Service Bulletin.
**SFE**: Synthetic Flight Examiner.
**SHK**: Statens Haverikommission.
**SL**: Service Letter.
**S/N**: Serial Number.
**T/O**: Take Off.

**TRE**: Type Rating Examiner.
**TRI**: Type Rating Instructor.
**TWR**: Aerodrome Control Tower.
**UTC**: Universal Time Coordinated.
**VFR**: Visual Flight Rules.
**VOR**: VHF Omnidirectional radio Range.

# FOREWORD

The accident occurred on April 30, 2016, at 09.35 UTC (11.35 local time), at Catania Fontanarossa airport, and involved the aircraft type Fokker F27 MK50 registration marks SE-LEZ.

The aircraft coming from Rimini with 18 passengers and 3 crew members on board, after a missed approach due to the indication in the cockpit that the nose landing gear was not extended, landed at Catania airport on the main gear only with the nose gear not extended. The aircraft landed on the front of the fuselage and remained on the runway. All occupants left the aircraft independently without injury.

ANSV was notified of the incident on the day of the event and carried out the first operational survey on May 1, 2016.

ANSV proceeded to send the notification of the event in question, in accordance with the relevant international and EU legislation (Annex 13 to the Convention on International Civil Aviation, EU Regulation 996/2010), to the following entities: SHK, DSB, and AAIB UK.

The above mentioned investigating authorities accredited their representatives in the investigation conducted by ANSV and have been supported by technical advisors, as provided by the above mentioned regulations.

All times mentioned in this report, unless otherwise specified, are expressed in **UTC** (Universal Time Coordinated), which on the date of the event corresponded to local time minus two hours.

# CHAPTER I

# FACTUAL INFORMATION

## 1. GENERAL

The following is an outline of the objective elements gathered during the safety investigation.

## 1.1. HISTORY OF THE FLIGHT

On April 30, 2016, the aircraft Fokker F27 MK50 registration marks SE-LEZ, operating Air Valleè flight number RVL233, took off from Rimini airport at 06.48 hrs with 18 passengers and 3 crew on board.

During the final approach to Catania airport, with the aircraft stabilized on ILS Z RWY 08, the crew noticed that the right and left main landing gear lights were green but the nose landing gear light was amber.

The crew informed the ATS (Catania APP) that they were in contact with the problem and informed them of their intention to continue the approach to perform a low pass on the runway followed by a standard missed approach procedure, in order to request a visual verification from the control tower of the actual extension of the nose gear.

During the low passage, the control tower informed the crew that the nose gear was not extended despite the opening of the nose gear compartment.

After the passage, all lights, including the amber light of the nose landing gear, went off. The aircraft proceeded to the INDAX point to perform a holding at an altitude of 3000 feet as agreed with ATS during which the crew applied the abnormal procedures for nose gear unsafe down after selection and alternate down procedures.

Both procedures were unsuccessful and the crew declared an "emergency" informing ATS of their intention to perform a final maneuver (leveled 2G turn). The captain of the flight, who had been PNF up to that moment, took the controls as PF and executed the turn: also in this case without any positive outcome.

The crew informed ATS of the situation, stating the number of passengers, the amount of fuel on board and the absence of dangerous goods. The crew decided to follow a VOR procedure for RWY26 followed by a visual approach in order to make a last low passage to check the condition of the nose gear. After this second missed approach, the aircraft was instructed to perform an ILS procedure for RWY 08.

Landing took place at 09:34 hrs with the main gear properly extracted and locked, the nose gear in "up" position and the doors open.

The following is a sequence of pictures taken from a video of the accident, acquired by ANSV through the Catania airport operator, in which the aircraft is seen landing with the nose landing gear not extended and touching the ground only when it reached the speed necessary to sustain it in the absence of nose landing gear support.

Photos 1, 2 e 3: photographic sequence of the landing.

After completion of the landing run, with the aircraft remaining in the middle of the runway, the engines were shut down and passengers and crew disembarked without further incident. Some of the passengers were transferred to the airport emergency room and subsequently some of them were sent to hospital for further examination; no passenger was reported to have sustained injuries as a result of the event.


Photo 4: the aircraft in its final stop position on the runway.

## 1.2. INJURIES TO PERSONS

| Injuries | Crew | Passengers | Total on board | Others |
|---|---|---|---|---|
| Fatal | 0 | 0 | | Not applicable |
| Serious | 0 | 0 | | Not applicable |
| Minor | 0 | 4 | | Not applicable |
| None | 3 | 14 | | Not applicable |
| Totali | 3 | 18 | 21 | |

## 1.3. DAMAGE TO AIRCRAFT

The aircraft showed damage due to sliding on the tarmac in the lower part of the fuselage, behind the nose gear compartment (attachment “A”).

The upper part of the fuselage, between the cockpit and the wing mount, was bent due to plastic deformation caused by upward bending of the structure.

The doors of the nose landing gear compartment were both damaged near their inner edges.

Inside the nose landing gear compartment, there was an interference between the two tires and the front vertical panel of the nose landing gear compartment, partially deformed by the interference with the wheels as shown in the following picture

Photo 5: nose landing gear compartment.

## 1.4. OTHER DAMAGE

No other damages.

## 1.5. PERSONNEL INFORMATION

### 1.5.1. Flight crew

***Captain***

| | |
|---|---|
| General information: | male, 44 years old, Italian nationality. |
| License: | ATPL(A), valid. |
| Current ratings: | F27, F27 IR, F50, F50 IR, IR ME MP. |
| Authorizations: | TRI F27, SFE F27, TRE F27. |
| English proficency level: | *level* 5, valid. |
| Medical: | valid 1st class medical examination. |

At the time of the accident the pilot had a total flight experience of 6850 hours of which 781 hours were on F 27 MK050 type aircraft. Of these 781 hours, 84 had been flown on simulator and 697 in flight. In the 90 days preceding the accident he had performed more than 10 take-offs and 10 landings on the aircraft type.

***First Officer***

| | |
|---|---|
| General information: | female, 32 years old, Italian nationality. |
| License: | ATPL(A), valid. |
| Current ratings: | F50, F50 IR. |
| English proficency level: | *level* 5, valid. |
| Medical: | valid 1st class medical examination. |

First officer flight experience: at the time of the accident the first officer had a total flight experience of 2680 hours. In the 90 days preceding the accident she had performed more than 10 take-offs and 10 landings on the aircraft type.

### 1.5.2. Cabin crew

Not applicable.

### 1.5.3. Maintenance personnel

The following provides information regarding the licenses and certifications of the three technicians who, on April 29, 2016, had performed the maintenance work reported in Section 1.6.3.

***Technician 1***

Male, 51 years old, Swedish nationality. Holder of a valid Part-66 aircraft maintenance license. Part-66 issued by the Swedish Aviation Authority valid. Part-66 type rating category B1 and B2 on Fokker 50/60 type aircrafts.

***Technician 2***

Male, 29 years old, Italian nationality. Holder of a valid Part-66 aircraft maintenance license issued by the Italian Aviation Authority. Part-66 type rating category A on aircraft type Fokker F27 and Fokker F 50.

***Technician 3***

Male, 46 years old, Italian nationality. Holder of a valid Part-66 aircraft maintenance license issued by the Italian Aviation Authority. Part-66 type rating category B1 and C on Fokker F27 and Fokker F 50 aircrafts.

### 1.5.4. ATS personnel

Non applicable.

## 1.6. AIRCRAFT INFORMATION

### 1.6.1. General information

Large high-wing, twin-turboprop "large aeroplane" category aircraft equipped with two 2500 shp Pratt & Whitney PW-125B engines and six blades propellers.

It has an MTOM of 20.820 kg.

The landing gear is of the retractable tricycle type, built by Messier-Bugatti-Dowty (currently part of the SAFRAN group).

The nose gear has a double axle and is equipped with an oleo-pneumatic shock absorber; it can be oriented by means of a "rack and pinion type" mechanism.

The technical and administrative documentation of the aircraft was issued by the Swedish Aviation Authority and was valid at the time of the accident.

The certificate of airworthiness had been renewed in Italy on June 29, 2015 with an expiry date of July 23, 2016.

The aircraft, owned by a Swedish company, was, at the time of the accident, operated by an Italian operator.

The Italian Civil Aviation Authority (ENAC) had been delegated to oversight the aircraft by the Aviation Authority of the state of registration (Sweden).

### 1.6.2. Specific information

***Aircraft***

| | |
|---|---|
| Manufacturer: | Fokker VFM B.V. |
| Model: | F27 Mark 050. |
| Serial number: | 20128. |
| Nationality and registration marks: | SE-LEZ. |
| Certificate of registration: | 6908 issued by the Swedish Aviation Authority on August 17, 2007. |
| Operator: | Air Vallée SpA. |
| Owner: | Largus Aviation AB. |
| Certificate of Airworthiness: | issued by the Swedish Aviation Authority on August 14, 2008. |

Airworthiness Review Certificate: issued on June 29, 2015 with expiry date July 23, 2016.

Maintenance program: maintenance program Air Valléee (Fokker 50) approved by ENAC.

Technical documentation compliance with current regulations/directives: yes.

From May 7, 2014 to April 28, 2017, on an annual basis, the technical and operational oversight of the SE-LEZ aircraft, as mentioned above, was transferred from the Swedish Aviation Authority to the Italian Aviation Authority (ENAC), according to the lease agreement in force between the owner of the aircraft (Swedish company Largus Aviation A.B.) and the operator of the aircraft (Italian company Air Vallee S.p.A.).

### 1.6.3. Additional information

***Recording of previous inefficiencies or malfunctions related to the event.***

| Data registrazione | Tipologia problematica | Provvedimenti adottati | Data rimessa in efficienza |
|---|---|---|---|
| 22.4.2016 | 1. After landing in Tirana we noticed short vibration on the nose landing gear and after arrival on parking stand T1 we found the NLG strut leaking. After 5 minutes NLG strut was completely down to the stop. | Ref DC LEZ 213 cleaned. NLG strut servicing performed satisfy. | 28/04/2016 |
| | 2. Perform DC LEZ 16/073. | DC LEZ 16/073 Performed FMS update. | 28/04/2016 |
| 29.4.2016 | 1. Security inspection search performed before departure in Tirana. | | |
| | 2. Security inspection search performed after arrival in Bergamo. | | |
| | 3. During cruise flight at FL200 overspeed warning on with 200KIAS →audio warning P/B set to off. | T/S performed found water in pitot line to ADC; system drained and checked with bench test satisfy. | 29/04/2016 |
| | 4. Perform W/R MNL BGY 16-006. | W/R MNL BGY 16-006 performed satisfy. | 29/04/2016 |

***Maintenance performed.***

The aircraft had undergone the following maintenance work on April 29, 2016.

1. Replacement of internal seals in the front landing gear damper due to hydraulic leakage and servicing of NLG damper.
2. FMS data update.
3. Functional test of transponder modes C and S.
4. Checking the presence of propeller root grease.
5. CND (eddy current) on inboard and outboard torsion beam STA.4052.

From the ATL copy, it appears that the aircraft, with the same crew on board, departed from Bergamo with destination Rimini at 17.25 hrs on April 29, 2016.

***Information about the front nose landing gear (NLG).***

The Nose Landing Gear of the Fokker 50, PN 201013001, SN DRG/2586/87 is of the retractable type and has a hydraulically operated rack and pinion steering mechanism; it also includes an oil-pneumatic shock absorber.

The shock absorber includes an upper part (Turning Tube in the following figure 1), inside which a Sliding Member slides, whose movement is supported by a bearing.

In the upper part of the Sliding Member a bearing and a valve are installed.

The upper stroke stop of the Sliding Member (out stop sub-assy) is screwed onto the Turning Tube and limits the upward movement.

The valve installed on the top of the Sliding Member includes a valve seat, drilled to allow oil circulation, a lock nut, a spring and the valve.

A bearing and its flanged sleeve are attached to the top of the Sliding Member.

4 locking cylinders (Dowel in the figure 1) lock the valve seat and the bearing sleeve to the Sliding Member.

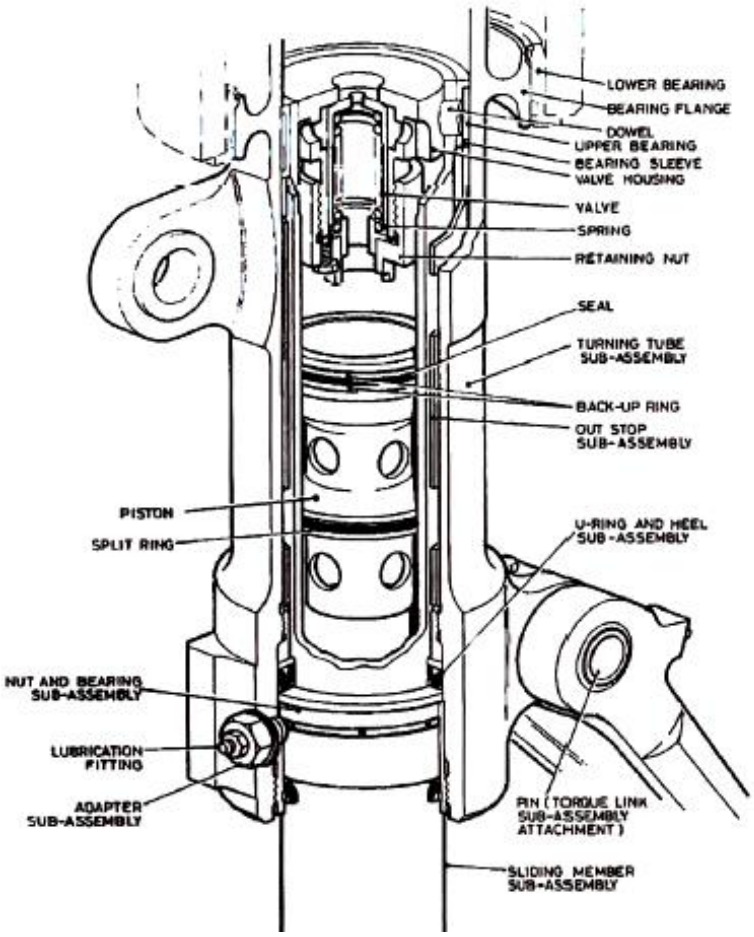



Figure 1: sectional view of the NLG damper.

Inside of the Sliding Member runs a piston whose seal is ensured by a gasket, and which separates the two chambers inside which we find the charge of nitrogen and hydraulic fluid that guarantee the cushioning effect.

When compression is applied to the shock absorber, the Sliding Member moves upwards inside the Turning Tube.

The chamber containing hydraulic fluid is pressurized, the fluid opens the valve on the Sliding Member and causes oil to flow through a hole in the valve seat in the hollow part of the Sliding Member. The piston inside the Sliding Member is pushed down and compresses the nitrogen in the lower chamber.

The compression force is gradually absorbed by the combined effect of pressurizing the nitrogen and reducing the oil flow.

Once the compression is removed from the shock absorber, the pressurized nitrogen will push the piston back up, resulting in an outflow of oil into the Turning Tube and closing the valve, through which minimal oil will be allowed to flow compared to the open valve.

## 1.7. METEOROLOGICAL INFORMATION

The meteorological conditions at Catania airport did not present critical elements correlated with the dynamics of the event:

METAR LICC300930Z 12009KT 100V160 9999FEW030 19/12 Q1018.

Dry runway, no rain.

## 1.8. AIDS TO NAVIGATION

Not applicable.

## 1.9. COMMUNICATIONS

The following is a transcription of the T/B/T communications between the aircraft and the Catania TWR.

| UTC | CALLING STATION | TEXT |
|---|---|---|
| 08.31.18 | RVL233 | Catania Buongiorno RVL233, full established ILS Z runway 08. |
| 08.31.25 | TWR | RVL233 buon giorno, runway 08, clear to land, 110° 8 knots. |
| 08.31.30 | RVL233 | Clear to land 08 RVL233. |
| 08.32.50 | RVL233 | Catania, Air Vallée 233. |
| 08.32.54 | TWR | Go ahead. |
| 08.32.55 | RVL233 | Abbiamo un problema con il *nose gear* ci dà indicazione non esteso o non completamente bloccato, potete aiutarci con un controllo visivo, faremo un *go around* standard. |
| 08.33.16 | TWR | Sì, ricevuto, allora faccia un basso passaggio, noi diamo un controllo visivo al carrello anteriore. |
| 08.33.25 | RVL233 | Affermativo. |
| 08.33.27 | TWR | Coordiniamo con l'Avvicinamento la procedura che seguirà. |
| 08.33.30 | RVL233 | Perfetto. |
| 08.34.00 | TWR | Air Vallée la informo che da questa posizione ci risulta in effetti non esteso, comunque continui e controlleremo meglio da vicino. |
| 08.34.11 | RVL233 | Ricevuto, grazie. |
| 08.35.22 | TWR | Air Vallée 233, la procedura sarà intanto INDAX 3000 piedi, le confermo i portelli del carrello anteriore sono entrambi aperti, ma il carrello non è giù. |
| 08.35.34 | RVL233 | Ricevuto, INDAX 3000, Air Vallée 233 *go around*. |
| 08.35.37 | TWR | Ricevuto può contattare sin da adesso l'Avvicinamento 119,250. |
| 08.35.48 | RVL233 | 119,250 Air Vallée 233, grazie. |
| 09.15.42 | RVL233 | Catania Tower Air Vallée 233 on MAYDAY, established on VOR, proceed runway 26, 6 miles we will perform a low passage to confirm the nose gear extended. |
| 09.16.08 | TWR | Air Vallée 233 copied, wind is 120° 7 knots, perform low pass to visual inspection nose gear. |
| 09.16.15 | RVL233 | Clear for low pass 233. |
| 09.16.26 | TWR | Air Vallée 233 after low pass runway heading maintain 4000 feet. |
| 09.16.38 | RVL233 | Runway heading maintain 4000, climb 4000 Air Vallée 233. |

| | | |
|---|---|---|
| 09.16.40 | TWR | Correct. |
| 09.18.49 | TWR | Air Vallée 233 Tower? |
| 09.18.52 | RVL233 | Catania Tower. |
| 09.18.54 | TWR | Air Vallée 233 nose gear is not extended, doors are open, gear is not extended. |
| 09.19.01 | RVL233 | Copied. |
| 09.19.08 | TWR | Climb 4000 feet and contact Approach 119,25. |
| 09.19.13 | RVL233 | Go around, 119,25, climb 4000, runway heading Air Vallée 233. |
| 09.29.35 | RVL233 | Catania Tower Air Vallée 233 on MAYDAY, established ILS runway 08. |
| 09.29.44 | TWR | Air Vallée 233 Catania Tower, runway 08, clear to land, wind 110° 9 knots, extreme direction from 090° to 150°. |
| 09.30.00 | RVL233 | Clear to land runway 08, Air Vallée 233. |

## 1.10. AERODROME INFORMATION

The airport of Catania/Fontanarossa (LICC) is an airport open to international traffic H24, its coordinates: 37°28'00 "N 015°03'50 "E; elevation 39 FT.

The type of traffic allowed is IFR/VFR, and the reference code Annex 14 ICAO for flight infrastructure is 4D.

The airport fire fighting service category is ICAO CAT 8.

The runway is asphalt, has designation 08-26, is 2436 meters long and 45 meters wide.

## 1.11. FLIGHT RECORDERS

The FDR was of the type L3 Communication mod. FA2100 P/N 2100-4043-00 S/N 000623422 version 840-E1655; the CVR was of the type L3 Communication mod. FA2100, P/N 2100-1020-00, S/N 000261694 SW 840-E1657.

During the course of the safety investigation, data was downloaded from the above mentioned equipment and information from the CVR confirmed what the pilots had stated and what was reported in the T/B/T recordings regarding the emergency management.

The data recorded by the FDR did not provide useful additional information regarding the nose landing gear malfunction.

## 1.12. IMPACT INFORMATION

### 1.12.1. Accident site

Catania airport (see paragraph 1.10).

### 1.12.2. Ground traces

Due to the runway closure to traffic at Catania Fontanarossa airport, as consequence to the aircraft removal, ANSV was able to reach the airport the day after the event.

While awaiting the arrival at the airport, ANSV gave useful instructions to the airport operator for the preservation of evidence of ANSV interest.

Figure 2 shows the runway traces on the ground.

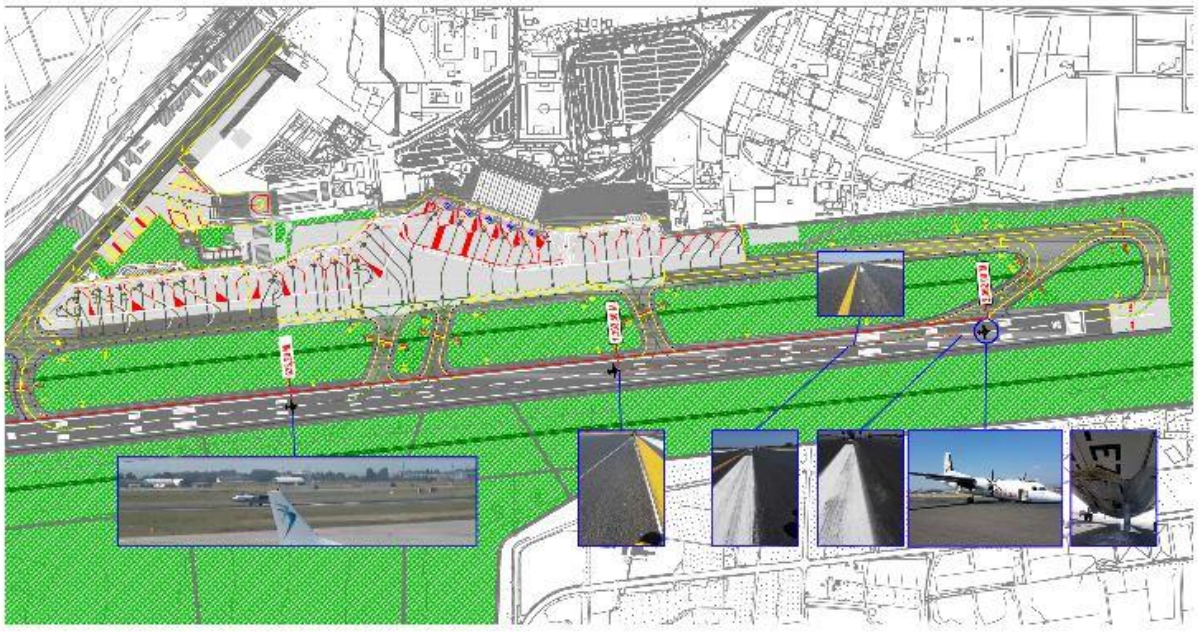


Figure 2: traces on runway.

The aircraft touched the ground with only its main gear at about 633 meters from the beginning of the runway and came to a complete stop after a distance of about 1430 meters: the front part of the fuselage of the aircraft crawled on the ground in the last 250 meters.

### 1.12.3. Examination of the aircraft

The aircraft was found damaged to the lower part of the fuselage, at the rear of the nose gear compartment (attachment A).

Photo 6: damages to the lower fuselage.

The front fuselage skin was bent in the upper part of the fuselage, between the cockpit and the wing mount, likely due to plastic deformation caused by upward bending of the structure.

The doors of the nose landing gear compartment were both damaged near their inner edges. Inside the nose landing gear compartment, there was an interference between the two NLG tires and the front vertical panel of the NLG compartment, partially deformed by the interference with the wheels, as shown in the following pictures.

Photos 7 and 8: nose landing gear compartment.

### 1.12.4. Landing gear

NLG investigation carried out at the manufacturer's facility.

On June 21 and 22, 2016 the investigation of the front landing gear was conducted at Smith Aerospace Ltd [1], in the presence of ANSV, UK AAIB and Safran personnel.

The investigation consisted in the removal of the wheels of the front landing gear and the disassembly of the shock absorber, during which visual analysis of the condition of individual parts, dimensional checks and measurements of oil levels and pressure of the gas charge inside the absorber were carried out.

During the investigation the following activities were performed and the following evidence was found.

- On arrival at Safran, the box containing the front landing gear force leg was found to have the seals placed by the ANSV investigators in Catania still intact.
- The component was found to be lying in a hyperextended position in the box, with the fixings repositioned to preserve the condition in which the component had been found on board the aircraft.
- In order to quantify the hyperextension of the shock absorber, the length of the shock absorber between the gland nut and the chrome plating of the sliding member was measured and found to be 422,3 mm; the same measurement was taken again after the correct reassembly of the upper stop of the sliding member and the locking cylinders (dowels), found to be 349,25 mm, thus leading to calculate the hyperextension of the shock absorber of 73,05 mm.
- The general condition of the NLG appeared normal, except for the position of the torque links and the sliding member (see following picture).

Photo 9: NLG in the containing box.

[1] In the present case, the Messier-Bugatti-Dowty nose landing gear had been manufactured by Smith Aerospace Ltd. in England on behalf of the French group. At the time of ANSV examination, the Messier-Bugatti-Dowty group had merged with Safran. The report with the results of the investigation conducted at the aircraft manufacturer is contained in attachment "B" to the *Interim Statement* of investigation published by ANSV (see: https://ansv.it/wp-content/uploads/2020/07/Dichiarazione-intermedia-SE-LEZ.pdf).

- With the component still inside the box, the nitrogen pressure was measured, using an analogue manometer: the measured pressure was 140 psi, lower than the expected value of 185-195 psi (as in the following picture).

Photo 10: nitrogen pressure measurement.

- The hydraulic fluid was drained from the shock absorber into a clean container; the amount of oil in the component was 2700 ml, 407 ml more than the expected volume of 2293 ml (see picture below).

Photo 11: hydraulic fluid draining.

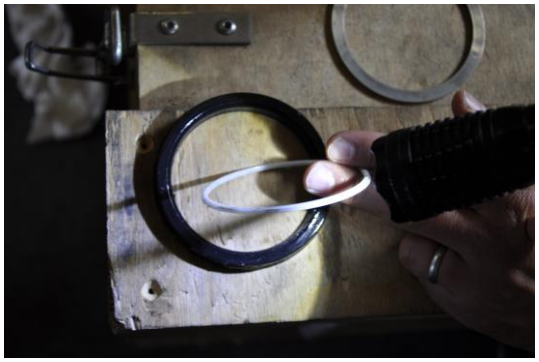
- The drained oil appeared clean, however a sample was taken for analysis, which subsequently ascertained that it was mineral oil, with an acceptable amount of water.
- The valve seat was found to be assembled with an incorrect orientation with respect to the applicable manuals.
- The Gland Nut was removed and a torque of 30-35 lb/ft was applied, well in excess of the 13.3-14.8 lb/ft tightening torque specified in the maintenance manual.
- The nut was removed to free the Sliding Member, an excessive play was immediately noticed, indicative of a probable separation of the upper bearing from the Sliding Member.
- After the removal of the Sliding Member from the Turning Tube, some metal fragments were collected and subsequently analyzed (see picture below).

Photo 12: metal particles.

- After the removal of the Sliding Member, the valve housing, the piston and the locking cylinders (dowel) at the top of the Turning Tube were visually observed (as per the following picture).

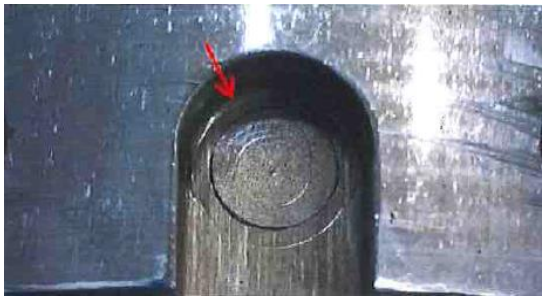
Photo 13: visual observation of the valve housing, piston and locking cylinders (dowels).

- Once these components were recovered, no breakage of the components was detected.
- Some marks were found on the valve seat orifice seats, indicative of an incorrect valve seat position during installation.
- There were some indentations on the surface of the sliding member, valve seat and bearing sleeve, indicative of the valve seat being installed in an improper orientation.
- The lettering on the surfaces of the valve housing, sliding member and bearing sleeve indicated that these components belonged to a post SB F50-32-60 configuration (see paragraph 1.18.).
- It was noted that the orienting line made on the bearing sleeve was oriented in the opposite direction to the line made on the sliding member and the valve housing.
- The gasket assemblies (gland u-ring backing ring and heel sub-assy) were removed, as they had been installed with an improper orientation, as well as the piston backing rings, installed underneath (see pictures below).




Photos 14 and 15: seal improper installation.

Investigation conducted at the manufacturer's laboratories revealed damage on the Valve Housing, as shown in the following pictures, which showed that the dowels had been installed in the Orifice Slots (U shaped) instead of the circular holes.




Photos 16 and 17: damages on the *valve housing*.

The findings of the investigation at SMITH Aerospace indicate that the hyperextension of the front landing gear was caused by the improper installation of the Sliding Member Valve Housing during the replacement of the internal Shock Absorber seals (Gland Seal and Separator Piston Seal).

Incorrect orientation resulting from the improper installation of the Valve Housing and the insertion of the dowels into the "U shaped" holes instead of the holes intended as their seat, allowed the dowels to fall through the Sliding Member, causing a loss of the upper stop of the Shock Absorber.

In addition to the improper Valve Housing installation, two of the internal Shock Absorber seals were also improperly installed.

The Shock Absorber was also found overfilled with hydraulic oil (407 ml in excess) and underfilled with nitrogen (140 psi instead of 185 psi).

At the end of the NLG investigation, the use of the following special equipment indicated by the AMM for the replacement of the Gland Seal and the Separator Piston Seal was analyzed:

- spanner nut and bearing assy NLG PN 460005796;
- spanner outstop NLG PN 460005797;
- spanner nut and bearing assy NLG.

It was ascertained that Miniliner 2.0 had forwarded a request to SMITH Aerospace Ltd to acquire the above equipment on June 1, 2016 (approximately one month after the accident), request subsequently fulfilled by SMITH Aerospace.

## 1.13. MEDICAL AND PHATOLOGICAL INFORMATION

Not applicable.

## 1.14. FIRE

Not applicable.

## 1.15. SURVIVAL ASPECTS

Not applicable.

## 1.16. TEST AND RESEARCH

Not applicable.

## 1.17. ORGANIZATIONAL AND MANAGEMENT INFORMATION

### 1.17.1. Italian operator

The operator of the aircraft at the time of the event was the Italian company Air Vallee S.p.A., holder of Air Operator Certificate issued by ENAC on 24/10/2014 and, as indicated in the relevant operations specification, was operating one aircraft only, type Fokker F27 50, registration marks SE-LEZ. Following the accident of the SE-LEZ aircraft, the company Air Vallee from June 1, 2016 suspended flight operations and in November 2016 the ENAC, suspended the company's air transport operating license.

### 1.17.2. Continuous Airworthiness Information and Maintenance Organization

The continuous airworthiness of the SE-LEZ aircraft was the responsibility of CAMO of Air Vallee but some tasks were sub-contracted to CAMO of Miniliner 2.0 under a contract between Air Vallee and Miniliner 2.0 as stated in the CAME document of Miniliner 2.0.

Miniliner 2.0 held the Continuing Airworthiness Management Organization Approval Certificate issued by the Italian Civil Aviation Authority (ENAC) on 23/10/2015.

The aircraft SE-LEZ appeared, from the CAME Miniliner 2.0 document, in the list of aircraft operated by the company Miniliner 2.0.

The company Miniliner 2.0 was also the holder of Maintenance Organisation Approval Certificate reference IT.145.0381 issued on 23/10/2015 and suspended on 13/11/2017 by ENAC with the following specification of the maintenance organisation ratings.

| **Classe** | **Abilitazioni** | | | |
|---|---|---|---|---|
| Aeromobili | A1 velivoli oltre 5700 kg | Fokker 50/60 Series | Sì (yes) | Sì (yes) |
| | | Fokker 27/Fairchild F27/FH227 | Sì (yes) | Sì (yes) |
| Componenti diversi da motori completi o APU | C5 impianto elettrico e luci | Secondo *capability list* riportata nel *Manuale* approvato | | |
| Processi speciali | D1 controlli non distruttivi | *Eddy current inspection* | | |
| | | *Liquid penetrant inspection* | | |
| | | *Magnetic particle inspection* | | |
| | | *Radiographic inspection* | | |
| | | *Ultrasonic inspection* | | |

The Regulation for the Maintenance Organization applicable on the date of the accident is:

- the Commission Regulation (EU) No 1321/2014 of 26 November 2014 as subsequently amended;
- EASA "Decision No 2015/029/R of 17 December 2015", which, regarding the Classes of Approvals, states:

**Part-145: Appendix II - Class and Ratings System used for the Approval of Maintenance Organisations referred to in Annex I (Part-M) Subpart F and in Annex II (Part-145)**

The provisions of Appendix IV to Annex I (Part-M) apply.

**Part-M: Appendix IV - Class and Ratings System to be used for the Approval of Maintenance Organisations referred to in Annex I (Part-M) Subpart F and Annex II (Part-145)**

4. A category A class rating means that the approved maintenance organisation may carry out maintenance on the aircraft and any component (including engines and/or Auxiliary Power Units (APUs), in accordance with aircraft maintenance data or, if agreed by the competent authority, in accordance with component maintenance data, only whilst such components are fitted to the aircraft. Nevertheless, such A-rated approved maintenance organisation may temporarily remove a component for maintenance, in order to improve access to that component, except when such removal generates the need for additional maintenance not eligible for the provisions of this point. This will be subject to a control procedure in the maintenance organisation exposition to be approved by the competent authority. The limitation section will specify the scope of such maintenance thereby indicating the extent of approval.

6. A category C class rating means that the approved maintenance organisation may carry out maintenance on uninstalled components (excluding engines and APUs) intended for fitment to the aircraft or engine/APU. The limitation section will specify the scope of such maintenance thereby indicating the extent of approval. A maintenance organisation approved with a category C class rating may also carry out maintenance on an installed component during base and line maintenance or at an engine/APU maintenance facility subject to a control procedure in the maintenance organisation exposition to be approved by the competent authority. The maintenance organisation exposition scope of work shall reflect such activity where permitted by the competent authority.

Therefore, the Maintenance Company was entitled to operate on Fokker 27 and 50 aircraft for the maintenance operations listed in the AMM.

As far as component maintenance is concerned, it could only be conducted on those components of the electrical system that had to be disembarked from the aircraft to be thoroughly maintained (e.g. batteries).

## 1.18. ADDITIONAL INFORMATION

***Audits conducted by ENAC on the maintenance company.***

Two Part 145 and Part MG audits of Miniliner 2.0 (previously Miniliner) have been carried out by the Civil Aviation Authority: the first ordinary audit on September 16, 2015 (7 months before the accident), the second extraordinary audit on May 3, 2016 (3 days after the accident).

The following are the findings made by ENAC that are of interest for the present investigation.

1. The NLG cleaning and refueling performed in Tirana on April 28, 2016 on the SE-LEZ aircraft as a correction of "NLG strut leaking and NLG strut completely down to the stop" does not appear appropriate.
2. Regarding the work reported in the MLN BGY 16-006 work report, classified as "line", the final CRS is signed by a Category B1.1 CS, even though it includes work not included in the Category B1.1 privileges and not included in the certification authorization. The same CS could have approved the work as category C if the work had been managed as part of a "base maintenance".
3. In some cases, including job card JC LEZ 16-089, there is no attestation of the execution of the steps of the work performed/sign-off [ref. AMC 145.A 65(b)3] [2].

[2] AMC mentioned in the Audit reports as follows: «In order to prevent omissions, every maintenance task or group of tasks should be signed-off. To ensure the task or group of tasks is completed, it should only be signed-off after completion. Work by unauthorised personnel (i.e. temporary staff, trainee...) should be checked by authorised personnel before they sign-off. The grouping of tasks for the purpose of signing-off should allow critical steps to be clearly identified. Note: A "sign-off" is a statement by the competent person performing or supervising the work, that the task or group of tasks has been correctly performed. A sign-off relates to one step in the maintenance process and is

4. The same job cards for the previous survey also lack the actual values of the measurements taken.

The following are *the responses* provided by Miniliner 2.0 to the ENAC findings:

1. The analysis of the event considered similar events in Miniliner 2.0, or reported in the Fokker Experience Digest, and the diagnosis is addressed on the possible displacement of the floating Gland Seal on the undercarriage strut, which has the function of sealing the shock absorber oil and oil seal. The Gland Seal is also subject to displacement simply by injecting grease into the "U" of the seal. 3 hypotheses were considered: NLG replacement in Tirana, replacement of the carriage rod seals, also in Tirana, intervention to ensure the good position and seal of the Gland Seal, as well as oil and nitrogen refill.
   We opted for solution 3. Hypothesis 1 and 2 required the aircraft to be put on jacks, but jacks and hangars were not available in Tirana. The corrective action was therefore limited to the verification of the correct position of the Gland Seal and full servicing. No further oil or nitrogen leakage occurred afterwards. At the request of the customer, it was decided to locate the aircraft in Bergamo in order to have a maintenance base for further operations. No oil or nitrogen leakage upon landing in Bergamo. Verbal request from the customer for replacement of all seals, due to the period of important activity.
2. The reported event was performed at the main base in Bergamo, as a Line Maintenance intervention, and was erroneously interpreted as a Base Maintenance intervention, although the format of the work report used was correct for Line Maintenance. It is proposed to intervene on the layout of the Work Report module for Line Maintenance (Mod. MNL03-line) reporting, in the part relating to the final CRS, in different options for type of CRS: B1A and B2, in order to avoid the occurrence of incorrect interpretations.
3. The current Miniliner 2.0 procedure envisages the signing of certificates of execution of groups of instructions only for task cards to which procedures from the Job Card Manual (JCM) are attached. These procedures are divided into paragraphs, each of which has a space for signatures. For task cards to which the AMM procedure is attached, the signature is affixed on the JCM in the space dedicated to the "Action taken" part, since the AMM task lacks the space for signatures.

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therefore different to the release to service of the aircraft. “Authorised personnel” means personnel formally authorised by the maintenance organisation approved under Part-145 to sign-off tasks. “Authorised personnel” are not necessarily “certifying staff”.».

4. When expressly required by the procedures, Miniliner 2.0 already reports the value of the measurements taken in the space provided in the procedures themselves; in the specific case (JC LEZ 16/089) the procedure does not require the measurement to be reported, but asks for the tightening to a prescribed value within a range of values. It is proposed to modify the Miniliner 2.0 procedure, introducing a preliminary check of the tasks to be AMM by the planning and/or engineering staff in order to highlight the critical steps and bring them to the attention of the Certifying Staff responsible for issuing the CRS (ref. 145.A.48). The person responsible for carrying out the work must sign beside the critical points highlighted by the planning and/or engineering.

***Maintenance procedures.***

Fokker, in 1994 and subsequently in 1997, through its Fokker 50/60 Service Experience Digest, dealing with "Landing Gear - Nose Gear - Nose Landing Gear failure to extend/incorrect installation of Dowels", had pointed out that some NLG failure events were attributable to improper installation of dowels in incorrect holes.

In order to prevent similar events the following actions had been taken.

- Fokker had sent a message to all operators in October 2004 regarding this issue.
- Messier Dowty had sent a SL to all operators who performed maintenance on Fokker 50/60.
- In January 1995 the procedure for the replacement of the gland seal and separator piston seal had been revised in the Fokker AMM and attention had been drawn to the possible improper installation of the dowels.

In January 1996 Safran (Messier Dowty Ltd) issued the SB F50-32-60, which modified the CMM with the instruction to etch reference lines on the valve housing and sliding member to ensure their correct alignment during installation, as shown in the following figures.

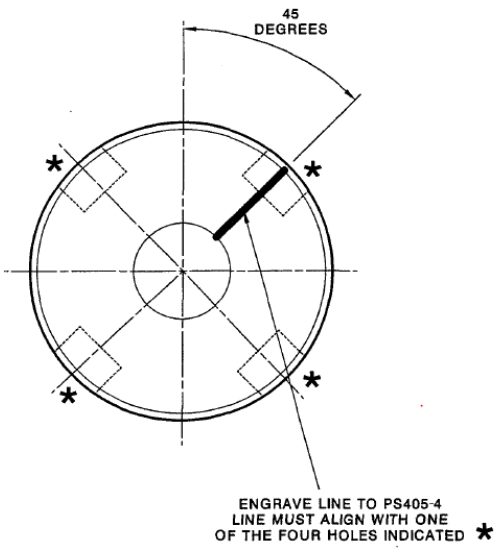



Figure 3: engrave line.

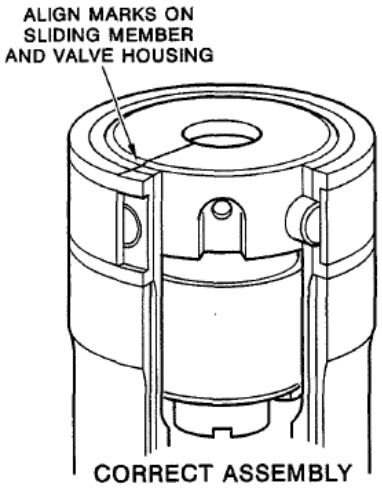



Figure 4: align marks between sliding member and valve housing.

In this regard, the following "CAUTION" was included in the CMM in October 1994, hence prior to the SB above.

The note (11) was included as a consequence of the publication of the mentioned SB.

**CAUTION: ENSURE CORRECT ALIGNMENT OF BEARING SLEEVE (4-125A), VALVE HOUSING (4-155) AND DOWELS (4-120). MAKE SURE THAT YOU DO NOT INSERT THE DOWELS IN THE DAMPING ORIFICE CUT OUTS INSTEAD OF THE DOWEL HOLES.**

(11) Insert the assembled valve details into the sliding member sub-assembly (4-180) and fit the bearing sleeve (4-125) onto the sliding member sub-assembly. Align the dowel holes and insert the dowels (4-120). On superseding installations a line is engraved on the sliding member (4-95) and on the top face of the valve housing (4-155) to indicate the centre line of one dowel hole dowel (4-120). These engraved lines will assist in the correct alignment of the valve housing (4-155), bearing sleeve (4-125) and sliding member sub-assembly.

For the replacement of the internal seals of the shock absorber and for its oil/nitrogen servicing, Fokker and Messier Dowty report in the AMM of the Fokker 50, the following three procedures:

1. TASK 32-21-06-400-814-A "Install the Sliding Member and the Gland Seal";
2. TASK 32-21-06-400-824-A "Install the Separator Piston Seal";
3. TASK 12-13-05-610-853-A "Fill and Charge the NLG Shock Absorber (Aircraft on Jacks)".

The three procedures, downloaded from the Fokker website on April 29, 2016 between 14:31 and 14:40 local time, were provided by Miniliner 2.0 attached to JC LEZ 16/089 which required to carry-out the work to which the three procedures refer.

The following is an excerpt from the final TASK 32-21-06-400-814-A, regarding the installation of the *sliding member* and the *gland seal*; in the procedure a "CAUTION" is dedicated to the correct installation of the dowels on the *valve housing*.



**TASK 32-21-06-400-814-A** - Install the Sliding Member and the Gland Seal
EFFECTIVITY: 001999

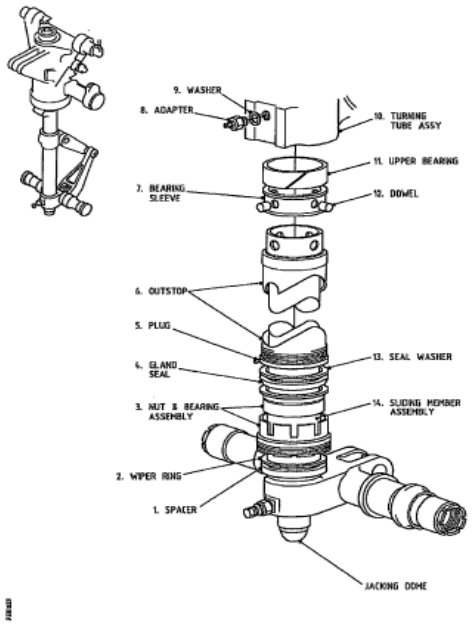
(6.) CAUTION: MAKE SURE THE DOWELS ARE IN THE DOWEL HOLES OF THE VALVE HOUSING. IF THE DOWELS ARE IN THE U-SHAPED SLOTS, THEY DO NOT LOCK THE VALVE HOUSING. DAMAGE CAN OCCUR.

Align the dowel holes of the valve housing, the sliding member assembly (14) and the bearing sleeve (7). Install the four dowels (12).

(7.) Install the upper bearing (11).
(8.) Use the gland-seal ring (tool No. 460005796) to install the sliding member assembly (14) in the turning tube assembly (10).
(9.) Remove the gland-seal ring (tool No. 460005796).
(10.) Put a support below the sliding member assembly (14).
(11.) Use the spanner (tool No. 460005797)to install the outstop (6). Torque the outstop (6) to 34 Nm (25 lbf.ft).
(12.) Use the spanner (tool No. 460005798)to install the nut and bearing assembly (3) on the turning tube assembly (10). Torque the nut and bearing assembly (3) to 34 Nm (25 lbf.ft).
(13.) Make sure a slot of the nut and bearing assembly (3) aligns with the adapter hole in the turning tube assembly (10).
(14.) If not, loosen the nut and bearing assembly (3) to align a slot with the adapter hole.
(15.) Install the washer (9) and the adapter (8). Torque the adapter to between 18 and 20 Nm (13.3 and 14.7 lbf.ft).
(16.) Safety the adapter (8) with wire, locking (material No. Fk05-047).
(17.) Remove the support from the sliding member assembly (14).
(18.) Remove the drain hose from the bleed valve and remove the container.



**TASK 32-21-06-000-814-A** - Remove the Sliding Member and the Gland Seal
EFFECTIVITY: 001999




Sliding Member - Removal
Figure 32-21-06-990-014-A00

Figure 5: TASK 32-21-06-400-814-A.

***Statements***

In the course of the investigation the pilots and the three technicians who performed maintenance activities on the NLG in the days preceding the accident were interviewed.

*Flight crew*

The statements made to ANSV by the captain and the first officer were substantially similar and described the dynamics of the events in accordance with the evidence acquired from radar traces and ground to ground radio communications.

- During the leg of the flight, which included departure from Rimini airport and subsequent landing at Catania airport, the first officer was acting as PF.
- Both pilots reported that immediately after take off from Rimini airport, while retracting the landing gear, they heard a noise more pronounced than usual, but since the hydraulic system pressure parameters were within normal limits and the landing gear transit lights were off, they continued with the normal operation of the aircraft.
- On approach to Catania airport, once stabilized on ILS RWY 08, the landing gear extension received a level 2 caution indication, together with the amber light on the landing nose position indicator. The main landing gear indicators displayed the correct extension and locking, with green lights.
- The crew continued the approach procedure, contacting the competent ATS office to inform them of the problem and express their intention to proceed to a low pass on the runway to confirm the condition of the nose gear.
- The crew contacted the ATS to inform them of the problem and the intention to proceed with a low pass over the runway to confirm the condition of the nose landing gear.
- Once confirmation was received that the main landing gear was extended, but not the nose landing gear, of which only the doors were opened, the crew performed the missed approach procedure; the main landing gear retraction took place without any problem.
- At this point the crew started holding on the INDAX fix, maintaining 3000 feet as instructed.
- The crew proceeded with the identification and troubleshooting, applying the abnormal procedures for nose gear unsafe down after selection and alternate down procedures, without success.
- The crew declared an emergency, stating that they intended to perform a final maneuver (level 2G turn) and that if this failed, they would make an emergency landing.
- The flight attendant and a second flight attendant, although off duty, were informed.

- The captain took control of the aircraft and performed the 2G turn maneuver without obtaining the desired result.
- The crew decided to execute a VOR RWY 26 approach, followed by a second low pass at 300 feet for a final visual confirmation by the TWR, which confirmed the opening of the doors of the nose gear, but the failure to release it. After go-around, the aircraft was vectored for an ILS procedure for RWY 08.
- During the approach the emergency procedure for nose gear up or unsafe was applied.
- Once on the ground and with the aircraft stationary, the pilot in command ordered an emergency evacuation, also due to smoke emanating from inside the cockpit.
- The evacuation took place through the right front door. Passengers were evacuated and removed from the aircraft with the assistance of the fire brigade and escorted to the airport first aid station.

*Technician 1*

One of the technicians, who for convenience will be referred as technician 1, of Swedish nationality, was not present at the premises of the Italian company that had performed the maintenance at the time of the interviews of the other two maintenance technicians.

His statement was obtained by ANSV through the Swedish investigation authority and supplemented by further clarifications. In particular, he reported the following.

- On Tirana airport, in the days preceding the accident, after having found the inefficiency at the NLG, reported on ATL on 23/4/2016, he carried out, in the absence of the necessary equipment to remove the internal seals of the NLG, a cleaning and refilling of the shock absorber of the NLG, in order to allow the airplane to return to Bergamo, where he would carry out the necessary replacements in the Miniliner 2.0 hangar.
- He had witnessed once as an observer and personally performed three times the operation of removing the sliding member and replacing the gland seal and separator piston seal.
- On April 29, 2016, as a member of the maintenance team applied to SE-LEZ, he started the removal activities of the sliding member NLG, disassembling also the related components, including the dowels. During the installation of the sliding member, after having installed the dowels in the circular holes provided, he removed the dowels as some components were missing to complete the installation. He would interrupt this activity to resolve the inefficiency related to overspeed warning and replacement of the life jackets.
- He remembers that the procedures for installation removals to be performed on the NLG were printed in black and white and were present near the NLG.

- He was back to the installation of the sliding member only once it had been fully assembled by the other team members and assisted to its installation on the NLG.
- The tools required by the AMM for the removal/installation of the upper and lower rings were not available in Bergamo, so they had proceeded to remove the lower ring nut using a hammer and screwdriver; for the upper ring nut a handmade wrench, locally built, was used.
- At the beginning of the work, no team leader had been appointed and no maintenance tasks had been assigned.
- The Italian members of the group communicated with each other in Italian, English to communicate with him.
- The activities carried out on April 29, 2016 in the Miniliner 2.0 hangar were characterized by considerable pressure and hurry exerted on the maintenance staff, in order to have the aircraft available as soon as possible, in order to land on Rimini and allow the crew to have rest time as scheduled[3].

*Technicians 2 e 3*

The other two technicians involved in the maintenance activity on April 29, 2016, who for convenience will be referred as Technician 2 (cat. A) and Technician 3 (cat. B1 and C), respectively, were both of Italian nationality and worked at Miniliner 2.0.

From their respective interviews, the following relevant information emerged.

- At the beginning of the sliding member removal, no task assignments were made, neither by technician 1 nor by technician 3, both B1 (the latter also C).
- The procedures for IAW AMM tasks 32-21-06-000-814A (removal of sliding member and glans seal), 32-21-06-000-824-A (removal of separator piston), 12-1305-610-853-A (refilling and loading of shock absorber NLG with aircraft on jacks), were printed and consulted during the work.
- For both Italian technicians, that was the first removal of the sliding member, replacement of the gland seal and separator piston seal.
- The removal/installation of the sliding member, the replacement of the grand seal, the separator piston seal and the refilling of the shock absorber were mainly carried out by technician 2, who signed the operations on the job card JC LEZ 16/089 as "mechanic". The same operations were signed as "certifying staff" by technician 3, even though the

[3] A review of the ATL would indicate that the time available to perform maintenance tasks was no more than 3h 30'.

same technician admitted that he did not check the correct execution of all the activities carried out by both technician 1 and 2.

- The technician 3, as certifying staff, signed the item "NLG o-ring replacement and servicing for caution" on the work report MNL BGY 16-006.

## 1.19. USEFUL OR EFFECTIVE INVESTIGATION TECHNIQUES

Not applicable.

# CHAPTER II
# ANALYSIS

## 2. GENERAL

The objective elements acquired in the course of the investigation, described in the previous chapter, are analyzed below. The objective of the analysis is to establish a logical link between the evidence acquired and the conclusions.

## 2.1. FLIGHT OPERATIONS

The flight was conducted by crew members in accordance with the rules and procedures applicable to the type of emergency that occurred (failure to extend the Nose Landing Gear).

## 2.2. AIRCRAFT

The aircraft sustained unavoidable damages due to runway friction with the forward lower part of the fuselage, as a consequence of missed NLG extension.

As previously mentioned, the aircraft had been subjected to maintenance the day before the accident, due to oil leakage from the nose landing gear.

The ATL of the aircraft showed:

- LDG block at Bergamo at 12.55 hrs of the aircraft coming from Tirana;
- following departure at 17.30' (T/O block) from Bergamo to Rimini.

The total stopover time was therefore 4h 25', of which about 3h 30' to perform the maintenance tasks.

## 2.3. HUMAN FACTOR IN MAINTENANCE OPERATIONS

### 2.3.1. Instructions in the procedures

As seen above, the maintenance personnel used the procedures on the AMM, two for replacing the seals inside the Shock Absorber of the NLG and another procedure for oil replenishment and nitrogen pressurization.

Regarding seals replacement, the two procedures printed and available to maintainers are TASK 32-21-06-400-814-A "Install the Sliding Member and the Gland Seal" and TASK 32-21-06-400-824-A "Install the Separator Piston Seal".

The evidence that emerged from the investigation was of incorrect orientation of the Valve Housing and installation of the dowels in the "U shaped" holes instead of the round holes, their correct location.

In the first of the following pictures, the wrong orientation of the Valve Housing is shown (red curved arrow) and the consequent wrong installation of the dowels in the "U shaped" holes (red arrow).

The second image shows the correct installation of the dowels.

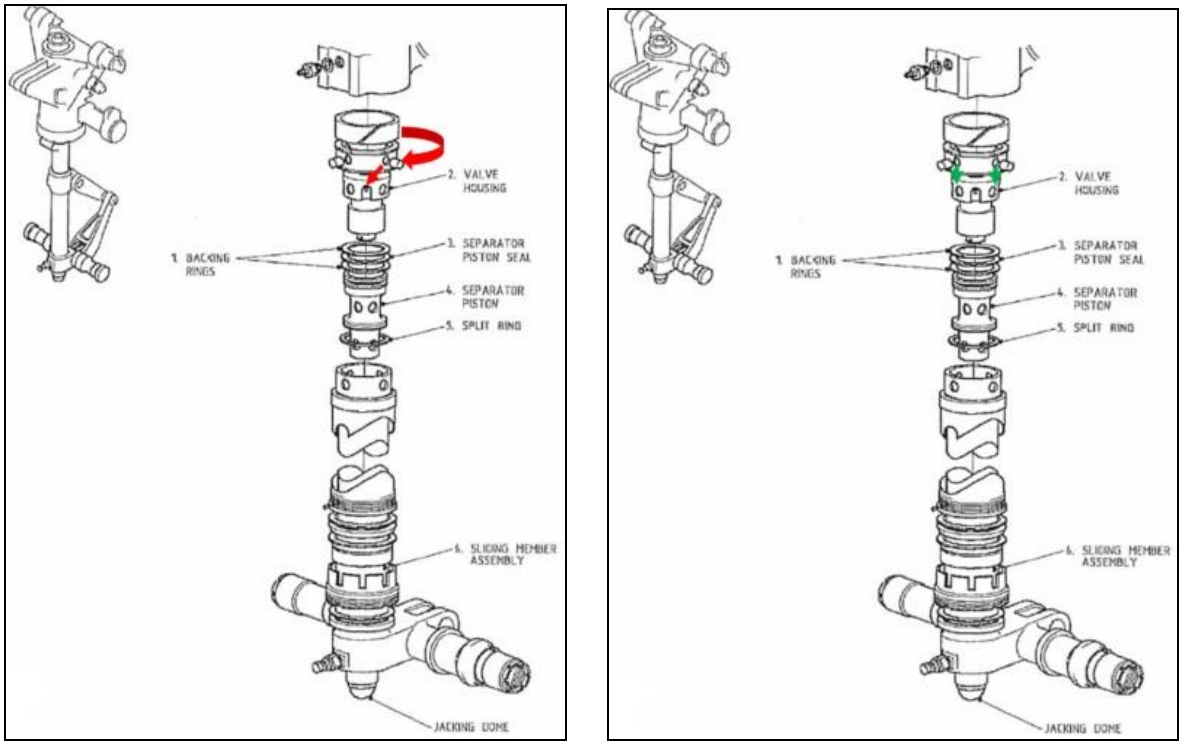



Figure 6 and 7: improper (left) and proper (right) installation of the *valve housing and dowels.*

Fokker, in 1994, and subsequently in 1997, through its Fokker 50/60 Service Experience Digest, dealing with "Landing Gear - Nose Gear - Nose Landing Gear failure to extend/incorrect installation of Dowels", had pointed out that some NLG failure events were attributable to improper installation of dowels in incorrect holes.

In order to prevent similar events, the following actions were taken, as mentioned above.

- Fokker had sent a message to all operators in October 2004 regarding the issue at hand.
- Messier Dowty had sent a SL to all operators who performed maintenance on Fokker 50/60.
- In January 1995 the procedure for the replacement of the gland seal and separator piston seal in the Fokker AMM had been revised and attention had been drawn to the possible

improper installation of the dowels. Messier Dowty carried out a similar review in its AMM.

- The AOM had been modified to include the alternative procedure for operating the airplane "to generate a 2G load when the NLG does not extend after an Alternate Down Selection.".

For the replacement of the internal seals of the shock absorber and for its oil/nitrogen servicing, Fokker and Messier Dowty report in the AMM of the Fokker 50 the following three procedures:

1. TASK 32-21-06-400-814-A "Install the Sliding Member and the Gland Seal";
2. TASK 32-21-06-400-824-A "Install the Separator Piston Seal";
3. TASK 12-13-05-610-853-A "Fill and Charge the NLG Shock Absorber (Aircraft on Jacks)".

In the TASK 32-21-06-400-814-A, concerning the installation of the sliding member and the gland seal, it is highlighted in amber color a "CAUTION" concerning the correct installation of the dowels on the valve housing.

In the procedure that follows, the "CAUTION" requires to align the holes of the 4 dowels of the valve housing with the holes on the bearing sleeve and to insert the dowels. In the figure to which the procedure refers, a section of which is shown below, the valve housing is not shown.

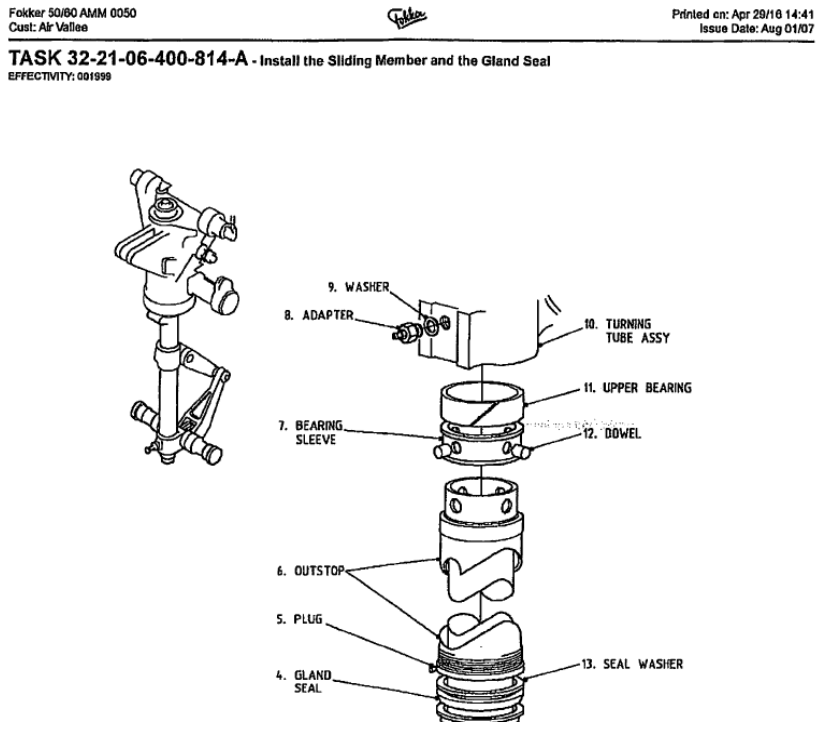



Figure 8: excerpt from TASK 32-21-06-400-814-A.

The valve housing is mentioned in the following procedure (TASK 32-21-06-400-824-A "Install the Separator Piston Seal").



**TASK 32-21-06-400-824-A** - Install the Separator Piston Seal
EFFECTIVITY: 001999

(b) Do the steps (2) thru (5) again, until the distance between the cut edges of the new split ring (5) is correct.
(c) Remove the sharp edges to a radius between 0,13 and 0,38 mm (0.005 and 0.015 in).
(6.) Remove the new split ring (5) from the sliding member assembly (6).
(7.) Install the new split ring (5) on the separator piston (4).
(8.) Lubricate the new backing rings (1) and the new separator piston seal (3) with the fluid, hydraulic (material No. Fk02-002).
(9.) Use the assembly post (tool No. 460005794) to install the new separator piston seal (3) and the new backing rings (1) on the separator piston (4).
(10.) Use the ring (tool No. 460003180/58) to decrease the size of the backing rings (1).
(11.)

CAUTION: BE CAREFUL WHEN YOU INSTALL THE SEPARATOR PISTON (4) IN THE SLIDING MEMBER ASSEMBLY (6). THE HOLES OF THE DOWELS CAN DAMAGE THE SEPARATOR PISTON SEAL (3) AND THE BACKING RINGS (1).

NOTE: **The separator piston (4) must be installed correctly in the sliding member assembly (6). Incorrect installation of the separator piston can change the operation of the shock absorber.**

Install the separator piston (4) in the sliding member assembly (6).
(12.) Install the valve housing (2) in the sliding member assembly (6).
(13.) Align the dowel holes of the valve housing (2) and the holes of the sliding member assembly (6).

SUBTASK 32-21-06-001-344-A00

C. Install the sliding member and the gland seal (Refer to 32-21-06, Pageblock 401) .

Figure 9: excerpt from TASK 32-21-06-400-824-A.

There is also a figure in that procedure that, unlike the figure in TASK 32-21-06-400-814-A, clearly shows the valve housing.

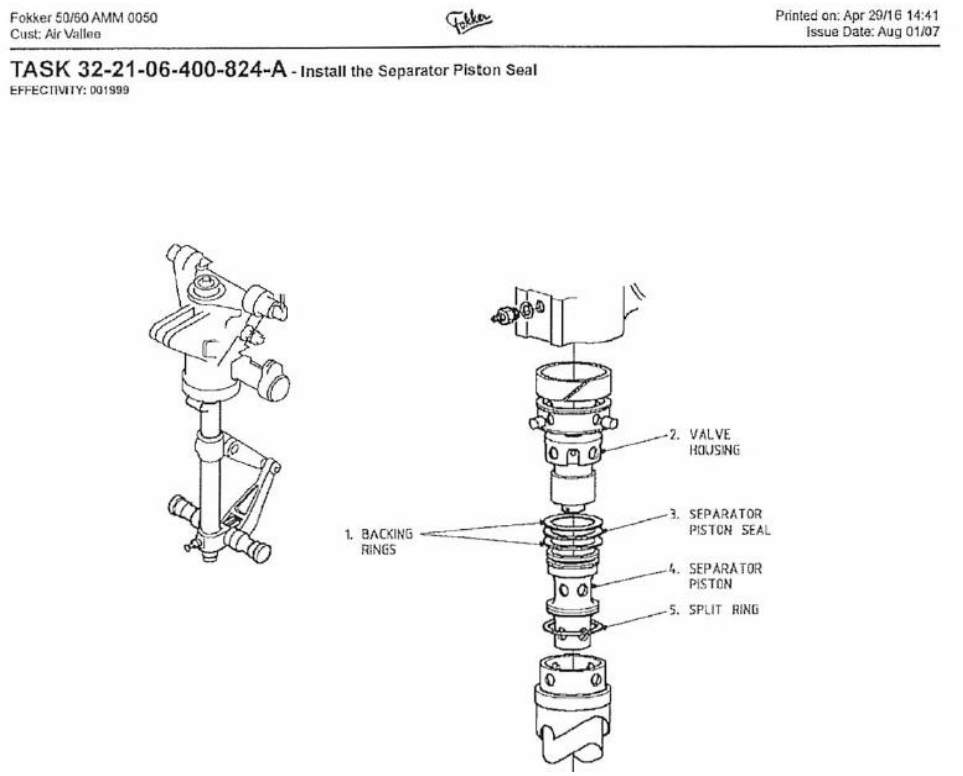



Figura 10: highlighting, in TASK 32-21-06-400-824-A, the valve housing.

It should be noted that in both of the above procedures there is no request to refer to the lines inserted with SB F50-32-60 and made on the valve housing and sliding member to ensure their correct orientation, as instead indicated in SB F50-32-60.

In terms of correct alignment, the CMM, unlike the AMM, reports more information.

Following the CAUTION below, there is a note (11), inserted in conjunction with the publication of the SB above, which clearly describes the need to align the valve housing to the sliding member by means of the reference lines, which is missing in the applicable procedures of the AMM.

**CAUTION: ENSURE CORRECT ALIGNMENT OF BEARING SLEEVE (4-125A), VALVE HOUSING (4-155) AND DOWELS (4-120). MAKE SURE THAT YOU DO NOT INSERT THE DOWELS IN THE DAMPING ORIFICE CUT OUTS INSTEAD OF THE DOWEL HOLES.**

(11) Insert the assembled valve details into the sliding member sub-assembly (4-180) and fit the bearing sleeve (4-125) onto the sliding member sub-assembly. Align the dowel holes and insert the dowels (4-120). On superseding installations a line is engraved on the sliding member (4-95) and on the top face of the valve housing (4-155) to indicate the centre line of one dowel hole dowel (4-120). These engraved lines will assist in the correct alignment of the valve housing (4-155), bearing sleeve (4-125) and sliding member sub-assembly.

The CMM of the NLG is a manual used when the component is removed from the aircraft and sent for maintenance/repair to the manufacturer/CAMO, while the Miniliner 2.0 maintenance personnel used the AMM as expected when maintenance is performed without disembarking the component.
The manufacturer Fokker, following the publication, on 16/3/2017, by ANSV, of the Interim Statement (see ANSV website), introduced "safety actions" by substantially modifying on 1/9/2017 tasks 32-21-06-000-814/824 and 32-21-06-400-814/824 of the AMM.
In detail, the major changes can be summarized as follows.

- AMM task 32-21-06-000-814 (Removal sliding member and gland seal), insertion of instructions on how to identify post SB F50-32-60 modifications, related to the lines on the sliding member and valve housing and, if not present, the realization of temporary reference lines on the above mentioned components.
- AMM tasks 32-21-06-000-814 and 32-21-06-400-814 (Remove/Install the sliding member and gland seal), insertion of pictures providing details about the reference lines on the sliding member and valve housing and the correct/correct positioning of the dowels.

In addition to the changes included in the AMM, the manufacturer informed operators in 2017 about what happened in the SE-LEZ accident and the actions taken, through the following publications:

- Airworthiness Recommendations Catalogue item 32-21-1;
- All Operators Message AOF50.066#02;
- Service Experience Digest item 32-21-003.

The procedure taken by the AMM and the others mentioned above had been printed by Air Vallée on April 29, 2016 and attached to JC LEZ 16/089, making them available to maintenance personnel.
In this regard, a discrepancy emerges between the documentation acquired from the operator (which reports the procedures printed in color) and the testimony of one of the maintenance personnel (who instead reports that the procedures in his possession were in black and white).

In case the procedures available to the maintenance personnel had been printed in black and white (as it would emerge from the testimonies), the visibility of the "CAUTION" in amber color would have been much less visible, as can be seen from the following picture,

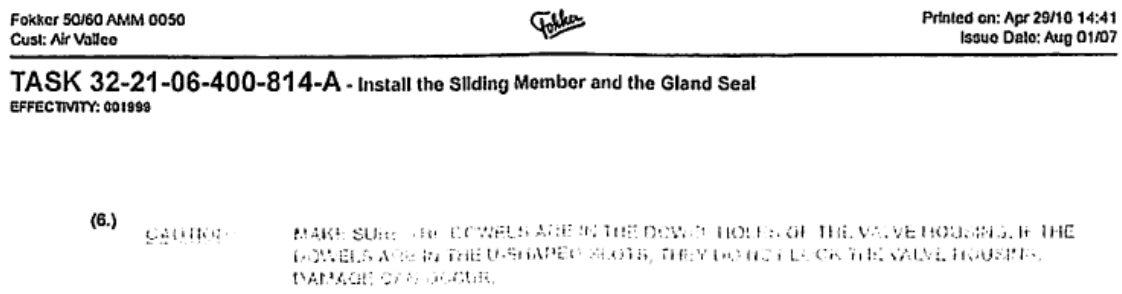

Fokker 50/60 AMM 0050
Cust: Air Vallee
Printed on: Apr 29/10 14:41
Issue Date: Aug 01/07
TASK 32-21-06-400-814-A - Install the Sliding Member and the Gland Seal
EFFECTIVITY: 001999
(6.)

Figure 11: “CAUTION” in amber colour, printed in black and white, present in the TASK 32-21-06-400-814-A.

### 2.3.2. Disapplication of procedures

Maintenance activities involving the NLG component were not conducted appropriately. Specifically, the following were found during the investigation.

1. Installation of the dowels in the U shaped holes instead of their simple circular shaped seats.
2. Improperly oriented valve housing installation, which likely also aided in improper dowel installation.
3. Improper installation of gland seal and separate piston seal.
4. Absorber refilled with excessive amount of oil (407 ml in excess).
5. Nitrogen charge pressure lower than expected.
6. Excessive calibration of the gland nut.

The above is indicative of work carried out without using the existing procedures for replacing the gland seal, separate piston seal and shock absorber servicing, even though these procedures were printed and available where the work was carried out.

It was also ascertained that the required tools were not used due to their unavailability (acquired after the work and after the accident).

Analysis of the interviews of the three maintenance technicians involved in the removal and installation of the shock absorber revealed a lack of identification of roles and tasks within the team, together with a lack of communication among the team members.

The most experienced maintenance technician should have exercised a leadership capable of coordinating and defining the work of the various members of the team already during the planning phase of the interventions foreseen on SE-LEZ.

In fact, it happened that the maintenance technician expert in that type of work only participated in the removal of the sliding member, and then went on to perform other tasks, deemed as urgent (life jackets and speed warning failure), and then returned to collaborate with the other two maintenance technicians only in the phase in which the sliding member was reinserted inside the shock absorber, that is when the operation, certainly critical, of orientation of the valve housing with the other components and the insertion of the dowels in their seats had already been carried out.

These last operations, as well as the other ones related to the installation of the new gaskets (gland and piston) on the sliding member were carried out by the less experienced maintenance technician, who had never carried out this type of intervention. The other maintenance technician, also at his first experience in gasket replacement, signed the work carried out as certifying staff, without asking, during the insertion of the sliding member, the maintenance technician with previous experience in that type of maintenance, task to carry out a check for the correctness of the operations carried out.

A decisive role in the manner in which the operations were carried out was played by the pressure exerted on the maintenance personnel, given the urgency, on behalf of CAMO, to restore the efficiency of the SE-LEZ within a few hours, thus avoiding that the designated crew went beyond the allowed working hours, in order to facilitate the redeployment of crew and aircraft on the same day to the Rimini base, from where the following morning the Rimini-Catania flight would have been operated.

In fact, as pointed out above, an examination of the ATL shows that the total time spent at Bergamo airport was 4h 25', of which, however, net of other activities (e.g. taxiing to/from hangar, aircraft preparation), only about 3h 30' to perform maintenance tasks.

### 2.3.3. Lack of quality controls

The engineering department of Miniliner 2.0, under request of the customer Air Vallée, had generated JC LEZ 16/089, in which the removal/installation of the gland and piston seals was requested, as well as the servicing of the NLG.

In the same JC, in the parts where a double control on the requested tasks is established, the options NO and NA were selected, indicating that the same department did not consider it necessary to carry out a double control or an independent control on the requested tasks.

As we have seen, among the three maintenance personnel who, although in different ways, contributed to the execution of the requested tasks, only one had experience in replacing internal gaskets, while for the other two it was the first time.

Given the nature of the tasks required and the inexperience of the personnel involved, double or independent supervision would have been essential to the success of the activities.

The investigation revealed several criticalities in the maintenance phase: improper installation of the dowels, improper servicing of the shock absorber (both in terms of oil quantity and nitrogen pressure), improper calibration of the refilling valve. These critical issues are indicative not only of the inexperience of those performing the work, but also of the fact that the procedures provided were not properly followed or understood.

Supervision or control of these activities by a maintenance person capable of performing effective control would almost certainly have prevented the errors from being committed.

## 2.4. SURVIVAL ASPECTS

Not applicable.

# CHAPTER III
# CONCLUSIONS

## 3. GENERAL

This chapter outlines the facts established during the investigation and the causes of the event.

## 3.1. FINDINGS

- The aircraft was in a current state of airworthiness.
- The flight crew had the required licenses and ratings to perform the flight.
- The Italian operator of the aircraft was holder, at the time of the accident, of the operating license and the certifications required by the current regulations (it subsequently ceased operations in November 2016, which had already been discontinued in June 2016).
- As of the date of the accident, the maintenance organization was holder of the capabilities and authorization to perform the maintenance work that preceded the event (it later ceased operations in November 2017).
- The Italian civil aviation authority (ENAC) had been delegated to oversee the aircraft by the civil aviation authority of the State of registry (Sweden).
- The meteorological conditions did not present critical elements related to the dynamics of the event.
- The maintenance personnel were holder of the required licenses and qualifications to carry out the work performed.
- Only one of the three maintenance technicians had previously carried out (three times) the replacement of the internal seals of the shock absorber, while the other two technicians had never carried out this operation.
- One of the technicians - who had never performed that kind of work - had performed and signed the three tasks related to the NLG.
- Another technician, also without specific experience, deliberated the seal replacement and servicing activities related to the shock absorber as certifying staff.
- The Miniliner 2.0 engineering department did not deem it necessary to provide for a double check with respect to the three maintenance tasks concerning the NLG.

- The maintenance personnel had available the procedures of the tasks to be carried out near where the work was done, with the same printed in black and white (as reported in the testimonials).
- On the NLG the fixing dowels of the valve housing to the sliding member and bearing sleeve have been installed in a wrong way.
- Gland and piston seals have been installed with wrong orientation.
- Servicing of the shock absorber was not conducted properly, both in terms of oil quantity and nitrogen pressure.
- The nitrogen supply valve has been over-tightened.
- The maintenance personnel employed worked without roles and tasks being clearly defined in the planning phase.
- A strong operational pressure acted on the employed technical staff, due to the urgency from CAMO to restore the efficiency of the SE-LEZ within a few hours.
- The personnel who worked on the NLG did not use the special tools foreseen by the procedures, as they were not available at Miniliner 2.0, but made use of handcrafted equipment made on site.
- The appropriate special tools have been ordered by Miniliner 2.0 from SMITH Aerospace after the execution of the work for which they should have been used.
- The procedures reported in the AMM regarding the replacement of the internal shock absorber seals did not mention the need to align the reference lines as reported in the CMM.
- The manufacturer, following the *Interim Statement* published by ANSV on 16/03/2017, has amended on 1/9/2017 the procedures for the replacement of the internal shock absorber seals, inserting additional notes and pictures useful for the identification of the correct alignment between sliding member and valve housing.

## 3.2. CAUSES

The accident was caused by the failure of the nose landing gear (nose gear up) due to over-extension of the shock absorber which caused interference between the tires and the NLG compartment and locked the NLG in a retracted position.

The over-extension was caused by the incorrect installation of some internal components of the shock absorber during the replacement of the internal seals the day before the accident.

The following factors contributed significantly to the improper activity conducted at maintenance:

- the insufficient experience of technical personnel in carrying out the maintenance tasks conducted on the NLG;
- the lack of controls on the operations carried out, deemed unnecessary by the CAMO engineering department;
- the lack of definition of roles and tasks during the planning phase of the maintenance work;
- the operational pressure on maintenance personnel, arising from the need to conclude maintenance operations quickly in order not to penalize the management of the aircraft;
- the insufficient clarity and lack of sensitive information in the maintenance tasks and related figures contained in the AMM, regarding the replacement of internal shock absorber seals, subsequently made clearer by the manufacturer;
- the reported black and white printing of the applied AMM procedures, which could have made the warnings in the manual barely legible.

# CHAPTER IV
# SAFETY RECOMMENDATIONS

## 4. RECOMMENDATIONS

Based on evidence gathered and analysis carried out, and especially the substantial changes included by the manufacturer in the applicable AMM procedures since the publication of the ANSV *Interim Statement* of investigation, it is not considered necessary to issue safety recommendations.

# ATTACHMENTS

**ATTACHMENT "A"**: photographic documentation.

***In the attached reproduced documents the anonymity of the persons involved is safeguarded, according to current dispositions regarding safety investigations.***


Photo 1: position of the aircraft immediately after the event, prior to removal from the runway.

Photo 2: aircraft final position on the accident site, along the runway axis.

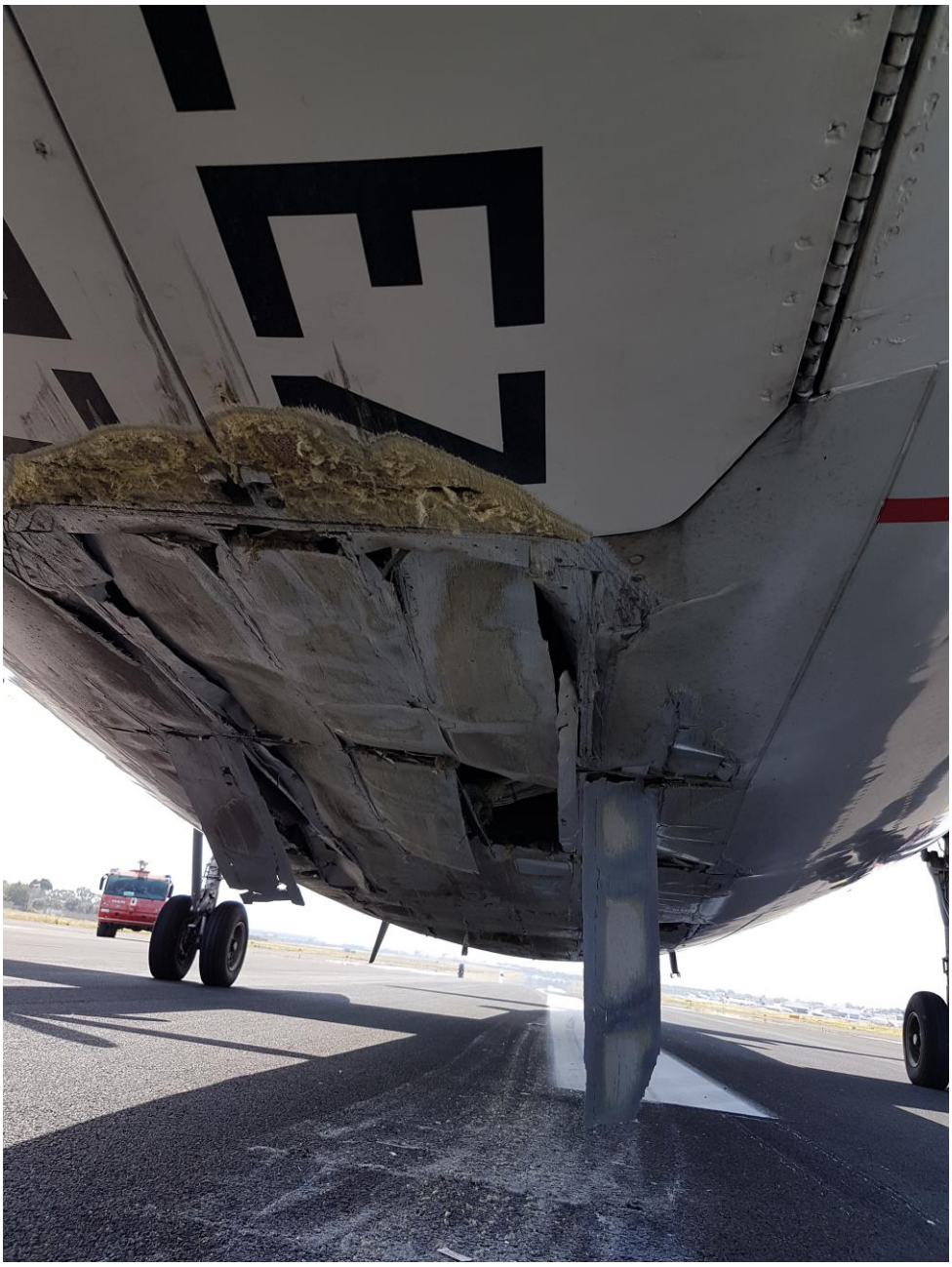


Photo 3: creep damage to the antero-inferior part of the fuselage.

Photo 4: position of the NLG after the event (hyperextended).