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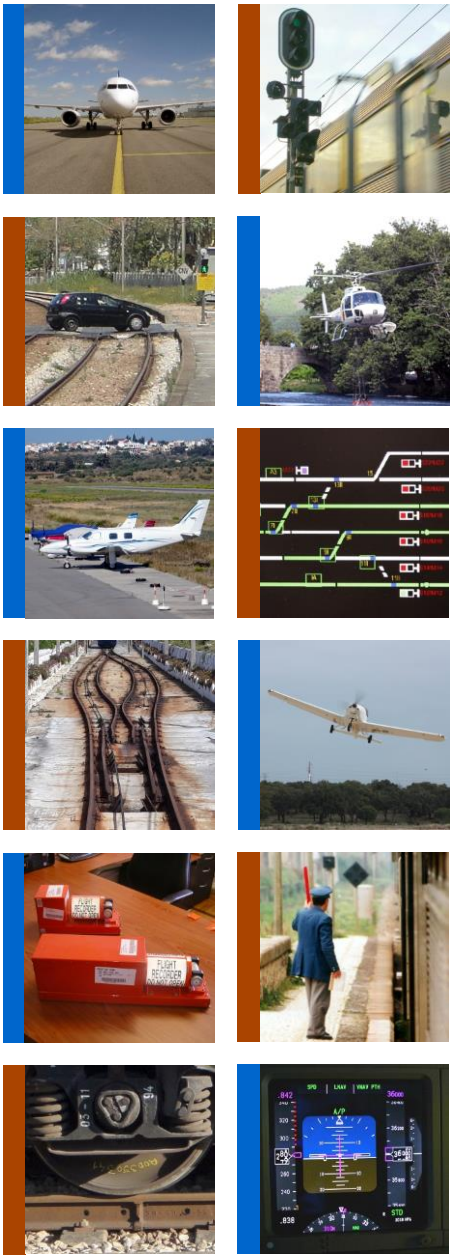
Gabinete de Prevenção e Investigação de Acidentes com Aeronaves e de Acidentes Ferroviários
Office for the Prevention and Investigation of Accidents in Civil Aviation and Rail (SIA/NIB PT)



AVIAÇÃO CIVIL

Aeródromo de Figueira de Cavaleiros (LPFC) Ferreira do Alentejo – PORTUGAL

19 de junho de 2016, 17:50 UTC

Falha de sistema/componente seguido de perda de controlo em voo

CIVIL AVIATION

Figueira de Cavaleiros aerodrome (LPFC) Ferreira do Alentejo – PORTUGAL

2016, June 19th, 17:50 UTC

System/component failure followed by loss of control - inflight

PILATUS PC-6

PARTICULAR / D-FSCB

RELATÓRIO FINAL DE INVESTIGAÇÃO DE SEGURANÇA

SAFETY INVESTIGATION FINAL REPORT

[07/ACCID/2016]

REPÚBLICA PORTUGUESA | PLANEAMENTO E INFRAESTRUTURAS

Nota: fotografia na capa por Rafael Vieira.

Note: photo on the cover by Rafael Vieira.

RELATÓRIO FINAL DE INVESTIGAÇÃO DE SEGURANÇA DE ACIDENTE

ACCIDENT SAFETY INVESTIGATION FINAL REPORT

PILATUS PC-6

D-FSCB

Falha de sistema/componente seguido de perda de controlo em voo

System/component failure followed by loss of control - inflight

AERÓDROMO DE FIGUEIRA DOS CAVALEIROS

LPFC

PORTUGAL

19 de junho de 2016 – 17:50 UTC

2016, June 19th – 17:50 UTC

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PREFÁCIO || FOREWORD

A investigação de segurança é um processo técnico conduzido com o único propósito da prevenção de acidentes o qual inclui a recolha e análise da informação, a determinação das causas e, quando apropriado, a formulação de recomendações de segurança.

Em conformidade com o Anexo 13 à Convenção sobre Aviação Civil Internacional, Chicago 1944, com o Regulamento (UE) n.º 996/2010 do Parlamento Europeu e do Conselho, de 20/10/2010, e com o n.º 3 do art.º 11º do Decreto-lei n.º 318/99, de 11 de Agosto, a investigação e o relatório correspondente não têm por objetivo o apuramento de culpas ou a determinação de responsabilidades.

NOTA IMPORTANTE:

Este relatório foi preparado, somente, para efeitos de prevenção de acidentes. O seu uso para outro fim pode conduzir a conclusões erradas.

Safety investigation is a technical process aiming to accidents prevention and comprises the gathering and analysis of evidences, in order to determine the causes and, when appropriate, to issue safety recommendations.

In accordance with Annex 13 to the International Civil Aviation Organisation Convention (Chicago 1944), EU Regulation Nr. 996/2010 from the European Parliament and Council (20th OCT 2010) and article 11, nr. 3 of Decree-Law nr. 318/99 (11th AUG 1999), it is not the purpose of any the safety investigation process and associated investigation report to apportion blame or liability.

IMPORTANT NOTE:

The only aim of this report is to collect lessons which may help to prevent future accidents. Its use for other purposes may lead to incorrect conclusions.

Este relatório foi publicado em duas línguas, Português e Inglês.

Em caso de discrepâncias, o texto em Português terá prevalência.

This report was published in two languages, Portuguese and English.

In the event of any discrepancy between these versions, the Portuguese text shall prevail.

ÍNDICE || TABLE OF CONTENTS

SECÇÃO || SECTION **PÁGINA || PAGE**

SINOPSE || SYNOPSIS

PROCESSO GPIAAF || GPIAAF PROCESS ID **07/ACCID/2016**			*Classificação || Classification* Acidente || Accident
			Tipo de evento || Type of event SCF-NP[1] - Falha de sistema/componente seguido de perda de controlo em voo || System/component failure followed by loss of control - inflight.
OCORRÊNCIA || OCCURRENCE			
Data || Date 19-06-2016	*Hora || Time* 17:50 UTC[2]	*Local || Location* Canhestros – Ferreira do Alentejo	*Coordenadas || Coordinates* 38°03'13.8"N 8°17'43.0"W
AERONAVE || AIRCRAFT			
Aeronave || Aircraft PILATUS PC-6		*N.º de série || Serial Nr.* 634	*Matrícula || Registration* D-FSCB
Categoria || Category Avião asa fixa || Fixed wing airplane			*Operador || Operator* Particular || Private
VOO || FLIGHT			
Origem || Origin Aeródromo Figueira de Cavaleiros (LPFC)		*Destino || Destination* Figueira de Cavaleiros Aerodrome (LPFC)	
Tipo de voo || Type of flight Trabalho Aéreo (Lançamento de paraquedistas) || Aerial Work (Parachute dropping).		*Tripulação || Crew* 01	*Passageiros || Passengers* 07
Fase do voo || Phase of flight Em rota || En-route		*Condições de luminosidade || Lighting conditions* Diurno || Daylight	

CONSEQUÊNCIAS || CONSEQUENCES			
Lesões || Injuries	*Tripulação || Crew*	*Passageiros || Passengers*	*Outros || Other*
Fatais || Fatal	01	-	-
Graves || Serious	-	02	-
Ligeiras / Nenhuma || Minor / None	-	05	-

Danos na aeronave || Aircraft damage Destruída || Destroyed	*Outros danos || Other damage* Nenhuns || None

O *PILATUS PC-6*, matrícula D-FSCB, descolou do Aeródromo de Figueira de Cavaleiros (LPFC), Canhestros, Beja, para um voo local de instrução e treino de paraquedistas, com 1 piloto e 7 paraquedistas a bordo.

O *Pilatus* descolou e iniciou uma subida para uma altitude de 14.500 pés. Durante a subida inicial à razão de 1.000 pés por minuto, aquando a cruzar os 7.000 pés acima do nível médio do mar, de acordo com alguns dos paraquedistas do grupo,

The PILATUS PC-6, registration D-FSCB, took off from Figueira de Cavaleiros Aerodrome (LPFC), Canhestros, Beja, for a local skydiver instruction and training flight with 1 pilot and 7 skydivers on board.

The Pilatus took off and started a climb to an altitude of 14.500 ft. During the initial climb at a rate of 1.000 feet per minute, when crossing 7.000 feet above mean sea level, according to some of the skydivers in the group, a sound

[1] SCF-NP - Falha ou mau funcionamento de um sistema ou componente de uma aeronave, não ligados a motores. || Failure or malfunction of an aircraft system or component - other than the powerplants.
[2] Todas as horas referidas neste relatório, salvo indicação em contrário, são horas UTC. || All times referred in this report, unless otherwise specified, are UTC time.

ouviu-se um som semelhante ao de partir/rasgar da estrutura de metal, sendo a aeronave submetida a uma guinada instantânea de nariz em cima e de rotação para o lado direito com grande instabilidade de voo. Subitamente toda a parte traseira da estrutura desintegrou-se.

similar to the cracking/ripping of a metal structure was heard, and simultaneously the aircraft pitched up to a high nose-up attitude while yawing to the right, causing a severe flight instability. Suddenly, the entire rear fuselage structure disintegrated.

De acordo com o relato, alguns ocupantes foram projetados contra a estrutura da aeronave antes de serem arremessados para fora. Nos segundos seguintes os paraquedistas que não sofreram lesões graves, conseguiram saltar do avião e acionar os respetivos paraquedas tendo, dois deles, sofrido lesões graves antes de saírem da aeronave, sendo acionado o paraquedas de emergência de abertura barométrica.

According to the report, some occupants were pushed against the structure of the aircraft before they were thrown out of the aircraft. During the following seconds the skydivers who did not suffer serious injuries, managed to jump out of the plane and triggered their parachutes. Two of them were seriously injured before leaving the aircraft, subsequently their emergency parachute was deployed by the barometric opening mechanism.

Como resultado, a desintegração das restantes partes do avião foi acontecendo até ao impacto final com o solo. Os fragmentos das partes da aeronave foram encontrados numa extensão de aproximadamente 1.500 metros numa faixa de cerca de 500 metros e estavam muito dispersos, apresentando um alinhamento com a direção do voo, de oeste para leste.

As a result, the disintegration of the remaining aircraft parts continued until the impact with the ground. Fragments of the aircraft parts were found over a length of approximately 1.500 meters and a width of about 500 meters and were widely dispersed, with an alignment with the direction of flight from west to east.

O piloto foi expelido do que sobrou do cockpit da aeronave e atingiu o solo a cerca de 400 metros do local de impacto da cabine. Ele não acionou o seu paraquedas e não estava, nem é procedimento estar equipado com um paraquedas de emergência com um mecanismo automático de abertura barométrica.

The pilot was thrown out of the remains of the cockpit and hit the ground at about 400 meters from the impact site of the cabin. He did not trigger its parachute and it was not, nor is it a procedure to be equipped with an emergency parachute with an automatic barometric opening mechanism.

Tipo de ocorrência || Occurrence type

SCF-NP - Falha de sistema/componente seguido de perda de controlo em voo.

SCF-NP - System/component failure followed by Loss of control - inflight.

GLOSSÁRIO || GLOSSARY

AAD	Sistemas automáticos de abertura dos paraquedas || Automatic Activation Device
ACFT	Aeronave || Aircraft
AMM	Manual de Manutenção da Aeronave || Aircraft Maintenance Manual
ANAC	Autoridade Nacional da Aviação Civil || National Civil Aviation Authority
AOC	Certificado de operador aéreo || Air Operator Certificate
AOM	Manual de operações da aeronave || Aircraft Operations Manual
CAMO	Organização de Gestão da Continuidade de Aeronavegabilidade || Continuing Airworthiness Management Organisation
CAT	Transporte Aéreo Comercial || Commercial Air Transport
COA	Certificado de Operador Aéreo || Air Operator Certificate
EASA	Agência Europeia para a Segurança da Aviação || European Aviation Safety Agency
Empa	Swiss Federal Laboratories for Materials, Science and Technology
FOCA	Federal Office of Civil Aviation (Switzerland)
FCOM	Manual dos pilotos de operação da aeronave || Flight Crew Operating Manual
FCTM	Manual de treino dos pilotos || Flight Crew Training Manual
FH	Horas de voo || Flight hours
FL	Nível de voo || Flight level
fps	Pés por Segundo || Feet per Second
ft	Pé ou Pés (unidade de medida) || Feet (dimensional unit)
g	Aceleração da Gravidade (9,81 m/s^2) || Acceleration due to Earth's gravity
GPIAAF	Gabinete de Prevenção e Investigação de Acidentes com Aeronaves e de Acidentes Ferroviários
hPa	Hectopascal
ICAO	International Civil Aviation Organization
kt	Nó (= 1 milha náutica/hora = 1,852 km/h) || Knot (= 1 NM/hour = 1,852 km/h)
LH	Esquerda || Left
MAC	Corda média aerodinâmica || Mean Aerodynamic Chord

METAR	Comunicado Meteorológico de Rotina || Meteorological Aerodrome Report
MTOW	Peso máximo de descolagem || Maximum takeoff weight
MZFW	Peso máximo zero combustível || Maximum zero fuel weight
NDT	Teste não destrutivo || Non Destructive Test
NOTAM	Aviso à Navegação || Notice to Air Men
OEM	Fabricante de equipamento original || Original Equipment Manufacturer
OM	Manual de operações || Operations Manual
PIC	Piloto Comandante || Pilot In Command
P/N	Número identificação do componente || Part Number
RH	Direita || Right
STOL	Descolagem e Aterragem Curtas || Short Take-Off and Landing
S/N	Número de série do componente || Part Serial Number
SOP	Procedimentos operacionais padronizados || Standard Operation Procedure
STSB	Swiss Transportation Safety Investigation Board
TSN	Tempo desde fabrico || Time Since New
TSO	Período de tempo desde grande inspeção || Time Since Overhaul
UTC	Tempo Universal Coordenado || Universal Time Coordinated
VDL	O piloto deverá usar lentes correctivas e ter consigo um par de óculos de reserva || The pilot shall wear corrective lenses and carry a spare set of spectacles
V_{NE}	Velocidade nunca exceder || Never-exceed speed

1. INFORMAÇÃO FACTUAL || FACTUAL INFORMATION

1.1. História do Voo || History of the Flight

Na tarde do dia 19 de Junho de 2016 uma aeronave *Pilatus PC-6*, com registo Alemão D-FSCB, descolou do Aeródromo de Figueira dos Cavaleiros (LPFC) para a sua 17.ª largada de paraquedistas nesse dia.

Neste voo seguiam 8 pessoas a bordo: 1 piloto, 5 paraquedistas e 2 passageiros que saltaram em *tandem* com dois dos paraquedistas.

A meteorologia apresentava um dia sem nuvens, o vento soprava de 040° com 10 kt de intensidade e a temperatura por volta dos 32° C.

O *Pilatus* descolou para um voo local de treino de paraquedismo iniciando uma subida para uma altitude de 14.500 pés. Durante a subida inicial à razão de 1.000 pés por minuto, aquando a cruzar os 7.000 pés acima do nível médio do mar, de acordo com alguns dos paraquedistas do grupo, ouviu-se um som semelhante ao de partir/rasgar da estrutura de metal, sendo a aeronave submetida a uma guinada instantânea de nariz em cima e de rotação para o lado direito com grande instabilidade de voo. Subitamente toda a parte traseira da estrutura desintegrou-se.

De acordo com o relato, alguns ocupantes foram projetados contra a estrutura da aeronave antes de serem arremessados para fora. Nos segundos seguintes os paraquedistas que não sofreram lesões graves, conseguiram saltar do avião e acionar os respetivos paraquedas tendo, dois deles, sofrido lesões graves antes de saírem da aeronave, sendo acionado o paraquedas de emergência de abertura barométrica.

Como resultado, a desintegração das restantes partes do avião foi acontecendo até ao impacto final com o solo. Os fragmentos das partes da aeronave foram encontrados numa extensão de aproximadamente 1.500 metros numa faixa de cerca de 500 metros e estavam muito dispersos, apresentando um alinhamento com a direção do voo, de oeste para leste.

On the afternoon of the 19th of June 2016 a Pilatus PC-6 aircraft, German registration D-FSCB, took off from the airfield of Figueira dos Cavaleiros (LPFC) for its 17th launch of skydivers that day.

On this flight there were 8 persons on board: 1 pilot, 5 skydivers and 2 passengers that were jumping in tandem with two of the skydivers.

The meteorology featured a day with clear sky, the wind blew from 040° with 10 kt and the air temperature was around 32° C.

The Pilatus took off for a local skydiving training flight and started a climb to an altitude of 14.500 ft. During the initial climb at a rate of 1.000 feet per minute, when crossing 7.000 feet above mean sea level, according to some of the skydivers in the group, a sound similar to the cracking/ripping of a metal structure was heard, and simultaneously the aircraft pitched up to a high nose-up attitude while yawing to the right, causing a severe flight instability. Suddenly, the entire rear fuselage structure disintegrated.

According to the reports, some occupants were pushed against the structure of the aircraft before they were thrown outside. During the following seconds the skydivers who did not suffer serious injuries, managed to jump out of the plane and triggered their parachutes. Two of them were seriously injured before leaving the aircraft, their emergency parachutes being automatically deployed by the barometric opening mechanism.

As a result, the disintegration of the remaining aircraft parts continued until the impact with the ground. Fragments of the aircraft parts were found over a length of approximately 1.500 meters and a width of about 500 meters and were widely dispersed, with an alignment with the direction of flight from west to east.

O piloto foi expelido do que sobrou do cockpit da aeronave e atingiu o solo a cerca de 400 metros do local de impacto da cabine. Ele não acionou o seu paraquedas e não estava, nem é procedimento estar equipado com um paraquedas de emergência com um mecanismo automático de abertura barométrica.

The pilot was thrown out of the remains of the cockpit and hit the ground at about 400 meters from the impact site of the cabin. He did not trigger his parachute and it was not, nor is it a procedure to be equipped with an emergency parachute with an automatic barometric opening mechanism.

Figura 1 || Figure 1
Mapa dos destroços || Map of the wreckage

Esta Autoridade de Investigação de Acidentes da Aviação Civil foi notificada imediatamente, e uma equipa foi enviada na manhã do dia seguinte para Ferreira do Alentejo, para iniciar a investigação de segurança.

Nos dias seguintes, a equipa de investigação de segurança foi apoiada por:

— Organismo homólogo suiço (*Swiss Transportation Safety Investigation Board - STSB*);

— Laboratório federal suíço para a ciência de materiais e tecnologia (*Empa*);

— Investigadores de Segurança da Pilatus;

— Organismo homólogo alemão (*BFU*).

The Portuguese Civil Aviation Safety Investigation Authority was notified immediately and a team was sent on the morning of the next day to Ferreira do Alentejo to start the safety investigation.

In the following days the safety investigation team was supported by:

— The Swiss Transportation Safety Investigation Board (STSB);

— The Swiss Federal Laboratories for Materials Science and Technology (Empa);

— Pilatus Air Safety Investigators;

— The German Federal Bureau of Aircraft Accident Investigation (BFU).

1.2. Lesões || Injuries

Lesões || Injuries	Tripulantes || Crew	Passageiros || Passengers	Outros || Others
Mortais || Fatal	1	0	0
Graves || Serious	0	2	0
Ligeiras || Minor	0	1	N/A
Nenhumas || None	0	4	N/A
TOTAL	1	7	0

1.3. Danos na Aeronave || Damage to Aircraft

A aeronave depois da falha de um componente/sistema, perdeu o controlo em voo e desintegrou-se.

A cauda separou-se da cabine, mantendo-se parcialmente intacta excepto o estabilizador horizontal esquerdo e leme de profundidade esquerdo que foi encontrado posteriormente.

The aircraft lost control in flight and disintegrated after a failure of an aircraft component/system.

The tail separated from the cabin and remained partially intact except for the left horizontal stabilizer and left elevator which was found later.

Figura 2 || Figure 2
Cauda do PILATUS PC-6 || PILATUS PC-6 Tail

As asas, direita e esquerda, ficaram separadas da fuselagem. Os seus componentes ficaram desagrupados e espalhados no terreno.

The right and the left wing were separated from the fuselage. The different parts of the wings were dispersed ungrouped on the ground.

Figura 3 || Figure 3
Asa esquerda e direita || Left and right wing

O motor e a cabine caíram no solo desagrupados dos restantes componentes da aeronave.

The engine and the cabin hit the ground aside of the remaining components of the aircraft.

Figura 4 || Figure 4
Motor e cabine || Engine and cabin

1.4. Outros Danos || Other Damage

Os diversos componentes da aeronave que se desintegrou no ar caíram num campo agrícola com sobreiros. Como resultado, não houve danos em pessoas, animais ou no montado.

The various components of the aircraft disintegrated in the air and hit the ground in an agricultural field with cork trees. As a result, there was no damage to the humans, animals or any structure.

Figura 5 || Figure 5
Asa esquerda no topo de um dos sobreiros || Left wing on top of one of a cork tree

1.5. Pessoas envolvidas || Personnel Information

1.5.1. Tripulação Técnica de Voo || Flight Crew

A tripulação técnica de voo era constituída por 1 piloto.

The flight crew consisted of 1 pilot.

O Piloto, de sexo masculino, tinha 27 anos à data do acidente e era de nacionalidade Belga.

The Pilot, male, was 27 years old at the date of the accident and held the Belgian citizenship.

Os seguintes dados foram recolhidos dos documentos pessoais do piloto:

The following data collected from the personal documents of the pilot:

	PILOTO || PILOT
DETALHES PESSOAIS || PERSONAL DETAILS	
Nacionalidade || Nationality:	Belga || Belgian
Data de Nascimento || Birth Date:	03-05-1989
LICENÇA DE TRIPULANTE TÉCNICO || FLIGHT CREW LICENCE	
Tipo || Type:	CPL(A)
Data de Emissão Inicial || Date of Initial Issue:	05-07-2012
Entidade Emissora || Issuing Authority:	Bélgica || Belgium
Data do Último Exame Médico || Last Medical Exam Date:	15-10-2015
Limitações || Limitations:	VDL

1.5.1.1. Qualificações || Rating

— MEP(land) - (31 Jan 2017);

— Pilatus PC-6 SET - (31 Mar 2018), qualificação em Abril 2014;

— SEP (land) - (31 Jul 2016);

— Noite;

— *Sailplane towing*;

— IR(A) SP/ME - (31 Jan 2017);

— National: PA-18 - (31 Jul 2016);

— Verificação de proficiência em Inglês (level 5) - (27 Set 2020);

— SC7 Skyvan (qualificado em Abril 2015, qualificação expirou em 30 Abril 2016);

— Última verificação realizada a 13 Maio 2015.

— MEP(land) - (31 Jan 2017);

— Pilatus PC-6 SET - (31 Mar 2018), qualification in April 2014;

— SEP (land) - (31 Jul 2016);

— Night;

— Sailplane towing;

— IR(A) SP/ME - (31 Jan 2017);

— National: PA-18 - (31 Jul 2016);

— English proficiency check (level 5) - (27 Sep 2020);

— Held a SC7 Skyvan rating (qualified in April 2015, rating expired 30 Apr 2016);

— Last prof check performed 13 May 2015.

1.5.1.2. Experiência de voo || Flight experience

O piloto começou o treino de voo em Maio 2005.

O piloto mantinha uma licença PPL desde 27 Setembro 2006.

Experiência de voo como PIC desde Maio 2005 até:

- Julho 2012: 468:42 FH (total)
- Abril 2013: 520 FH
- Abril 2014: 588 FH
- Abril 2015: 1.500 FH
- 19 Junho 2016: 2.196 FH
- Abril 2014 a Abril 2015, Tailândia: Experiência de largada de paraquedistas.

  Fez mais de 900 horas de voo no *Pilatus PC*-6 porter e tinha um tempo de voo total de mais de 1.400 horas.

The pilot started flight training in May 2005.

The pilot held a PPL licence that he received on 27 September 2006.

PIC flight experience from May 2005 to:

- July 2012: 468:42 FH (total)
- April 2013: 520 FH
- April 2014: 588 FH
- April 2015: ca 1.500 FH
- 19 June 2016: 2.196 FH
- April 2014 to April 2015, Thailand: Parachute drop experience.

  Gained more than 900 hours on the Pilatus PC 6 porter and had a total flight time of more than 1.400 hours.

1.5.1.3. Atividades de voo na semana do acidente || Flight activities on the week of the accident

Data || Date (2016)	Tempo || Duration	Aterragens || Landings
16 Junho	04:10	3
17 Junho	02:15	4
18 Junho	05:45	23
19 Junho Dia do acidente || day of accident	04:06	16

1.5.2. Passageiros || Passengers

A aeronave transportava 7 passageiros, sendo 5 paraquedistas e 2 passageiros que se preparavam para efetuar um salto em *tandem*. Dois dos paraquedistas sofreram lesões graves.

The aircraft was carrying seven passengers, 5 skydivers and 2 passengers that were performing a tandem jump with two of the skydivers. Two of the skydivers suffered serious injuries.

1.6. Informação sobre a Aeronave || Aircraft Information

1.6.1. Generalidades || General

O *Pilatus PC-6* é um monomotor de asa alta *Short Take-Off and Landing (STOL)* aeronaves de serviço com trem de aterragem fixo convencional, desenhado por *Pilatus Aircraft* da Suíça. Começou a voar em 1959, o PC-6 foi construído com motor a pistão e também com versões turboélice alimentado. O avião do acidente estava equipado com um motor de turbina livre P&WC PT6A-34, depois de cumprido o respetivo STC.

The Pilatus PC-6 is a single-engine high wing Short Take-Off and Landing (STOL) utility aircraft with conventional fixed landing gear, designed by Pilatus Aircraft of Switzerland. First flown in 1959, the PC-6 has been built in both piston engine and turboprop powered versions. The accident aeroplane was powered by a P&WC PT6A-34 free turbine engine, after an STC accomplishment.

1.6.2. Certificação || Certification

A primeira versão do *Pilatus PC-6* foi certificada pela Federal Aviação Civil da Suíça (FOCA), em dezembro de 1959, sob a referência Tipo de Certificado F 56-10. A aeronave está em conformidade com os Regulamentos Civis da Aviação dos EUA, parte 3 (US CAR3) como um avião de categoria normal. O PC-6 não está aprovado para manobras de acrobacias. O modelo variante PC-6/B2-H4 foi aprovado em 20 de Novembro de 1985.

The Pilatus PC-6's first version had been certified by the Federal Office for Civil Aviation (FOCA) of Switzerland in December 1959, under the Type Certificate reference F 56-10. The aircraft complies with the US Civil Air Regulations, Part 3 (US CAR3) as a normal category aeroplane. PC-6 is not approved for aerobatics manoeuvres. The model PC-6/B2-H4 variant had been approved on 20 November 1985.

1.6.3. Características Gerais da Aeronave || A/C Generic Characteristics

- Tripulação: um piloto
- Capacidade: até dez passageiros
- Comprimento: 10,90 m
- Envergadura: 15,87 m
- Altura (estático): 3,20 m
- Área da asa: 30,15 m²
- Peso vazio: 1.359 kg
- MTOW: 2.800 kg
- MZFW: 2.400 kg
- Centro de Gravidade envelope: Até 1.450 kg = 11% a 38% MAC (3,209 m para 3,722 m da linha de referência).
- Com 2.800 kg = 32% a 38% MAC (3,608 m a 3,722 m a partir da linha de referência).
- Linha reta entre pontos de variação.
- MOTOR: P&W Canada PT6A-34 turboélice, 550 SHP, o motor foi instalado de acordo com um STC (certificado de tipo suplementar)
- Velocidade nunca exceder (VNE): 280 km/h (151 kt)
- Max estrutural cruzeiro (VC): 220 km/h (119 kt)
- Max Manobra (VA): 220 km/h (119 kt)
- Max *Flaps* estendidos (VFE): 176 km/h (95 kt)
- Velocidade de perda (VS): 96 km/h (52 kt) (*Flaps* em baixo, sem potencia, MTOW)
- Fatores de carga na manobra: + 3,58 - 1,43
- Teto de serviço: 25.000 ft

- Crew: one pilot
- Capacity: up to ten passengers
- Length: 10,90 m
- Wingspan: 15,87 m
- Height (Static): 3,20 m
- Wing area: 30,15 m²
- Empty weight: 1.359 kg
- MTOW: 2.800 kg
- Max zero fuel weight: 2.400 kg
- Centre of Gravity envelope: Up to 1.450 kg = 11% to 38% MAC (3,209 m to 3,722 m from the reference line).
- At 2.800 kg = 32% to 38% MAC (3,608 m to 3,722 m from the reference line).
- Straight line between variation points.
- Powerplant: P&W Canada PT6A-34 turboprop, 550 SHP, the engine was installed according to an STC (supplemental type certificate)
- Never exceed speed (VNE): 280 km/h (151 kt)
- Max Structural cruising (VC): 220 km/h (119 kt)
- Max Manoeuvring (VA): 220 km/h (119 kt)
- Max flaps extended (VFE): 176 km/h (95 kt)
- Stall speed (VS): 96 km/h (52 kt) (flaps down, power off, at MTOW)
- Manoeuvring load factors: + 3,58 – 1,43
- Service ceiling: 25.000 ft

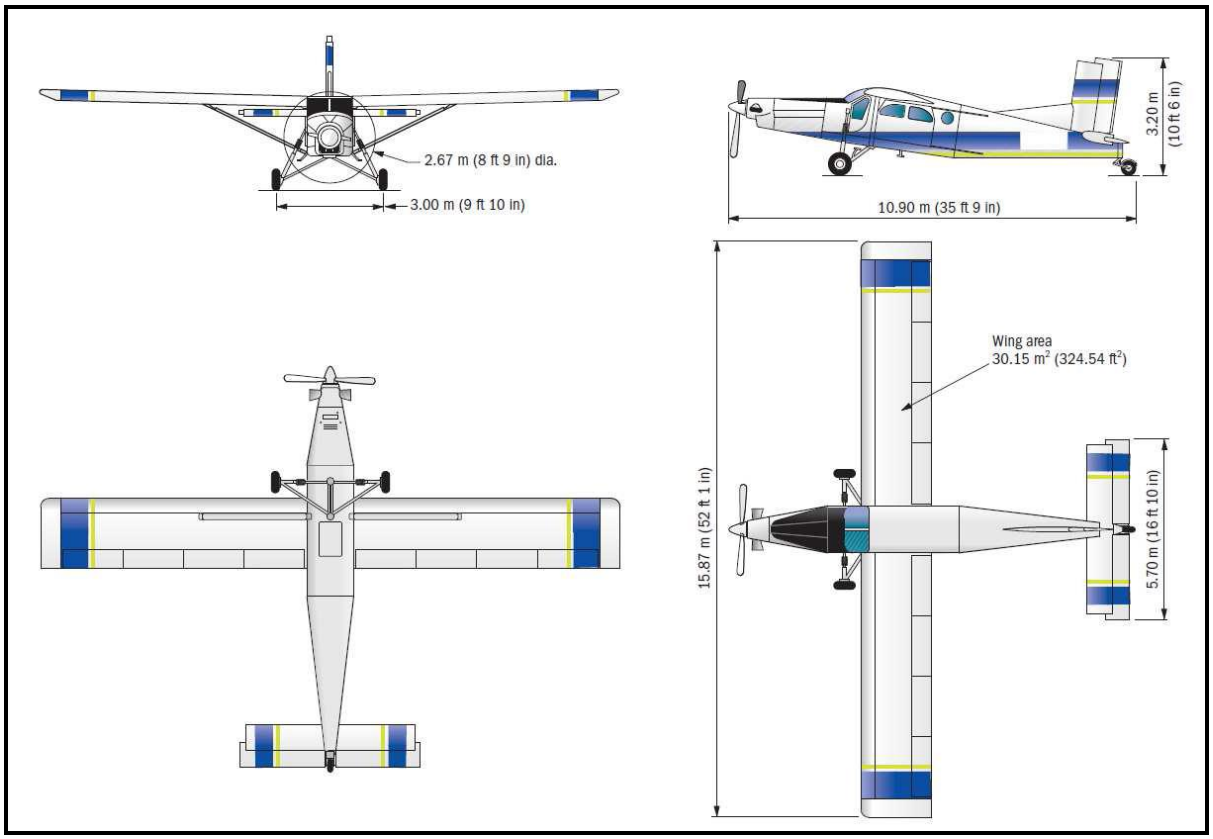


Figura 6 || Figure 6
Pilatus PC-6 B2H4

Referência || Reference	**Aeronave || Airframe**	**Motor || Engine**	**Hélice || Propeller**
Fabricante || Manufacture	Pilatus	Pratt and Whitney Canada	Hartzell (FAA STC SA377CH)
Tipo/Modelo || Type/Model	PC-6/B2-H4	PT6A-34	HC-D4N-3P
N.º de Série || Serial Nr	634	PCE-RB 0247	FY 3172
Ano de construção || Year of construction	1967	-	-
Tempo desde Novo || T S N	6.556:14	-	-
Tempo desde Revisão ||T S O	-	2.135:36	-
Data da última Inspeção || Last Insp. Date	2016-06-16	2016-06-16	2016-06-16

1.6.4. Navegabilidade e Manutenção || Airworthiness and Maintenance

A aeronave com a matrícula D-FSCB tinha todas as Licenças e Certificados de Aeronavegabilidade válidas. De acordo com o programa CAMO, a documentação técnica e de manutenção do avião foram realizadas regularmente.

The aircraft with registration D-FSCB had all Licenses and Airworthiness Certificates valid. According with CAMO program the airplane technical and maintenance documentation was regularly performed.

1.6.4.1. Seguimento das operações de manutenção || Maintenance operations follow-up

A aeronave era mantida por uma organização de manutenção EASA Part M subparte F. Esta organização estava também devidamente aprovada como uma organização de gestão de aeronavegabilidade contínua (CAMO) e como tal, responsável tanto pela manutenção quanto pela gestão da aeronavegabilidade do avião.

The aircraft was maintained by an EASA Part M subpart F approved maintenance organization. This organization was also duly approved as a Continuing Airworthiness Management Organization (CAMO) and as such was in charge of both the maintenance and the airworthiness management of the airplane.

Os registos mostram que a manutenção foi realizada regularmente em outras organizações parte 145 aprovadas, seguindo o "programa de manutenção de aeronave aprovado".

Records show that the maintenance was regularly performed within another approved PART-145 organizations, following approved “Aircraft Maintenance Program”.

A última manutenção periódica (100 h) tinha sido realizada em 16 de junho de 2016 com 6.541:55 FH (tempo total de estrutura do avião). A inspeção foi conduzida de acordo com o fabricante do avião e não revelou nenhuma anomalia.

The last periodical maintenance (100 h) had been performed on 16 June 2016 at 6.541:55 FH (Airframe Total Time). The inspection was conducted according by the airplane manufacturer and had revealed no anomalies.

A ANAC emitiu em 21 de dezembro de 2015, uma autorização (N.º05/2015-VCA) ao operador da aeronave para a livre prestação de serviços de trabalho aéreo em espaço sob jurisdição nacional. Não foi evidenciado pela autoridade nacional (ANAC), uma supervisão efetiva a um operador não nacional, com controlo de aeronavegabilidade não nacional e efetuando todas as inspeções periódicas de manutenção fora de Portugal.

On December 21, 2015, ANAC issued an authorization (No. 05/2015-VCA) to the aircraft operator for unrestricted aerial work services provider in national airspace. It was not evidenced by the National Authority (ANAC), an effective oversight to the non-national operator with foreign airworthiness control, as well performing all periodic maintenance inspections outside of Portugal.

1.6.4.1.1. Inspeções Estruturais Obrigatórias || Mandatory Structural Inspections

De acordo com o manual de manutenção do Pilatus PC-6 a fixação do atuador do compensador de profundidade deve ser inspecionado e examinado de acordo com AMM, 53-30-00 a cada 3.500 horas de voo ou 7 anos, o que ocorrer primeiro.

According to the Pilatus PC-6 maintenance manual the horizontal stabilizer trim actuator attachment must be inspected and examined according to AMM, 53-30-00 every 3.500 flight hours or 7 years, whichever occurs first.

Chapter 53 - Fuselage Stabilizer Trim Attachment Components, FR12A	Examine (Ref. 53-30-00. Page Block 601)	3500 flying hours or 7 years (whichever comes first) See NOTE C below

O CAMO afirma que a última inspeção Dye-penetrante foi feita em 2015 como parte de uma revisão parcial. Contudo, apenas foi possível evidenciar inspeção efetiva à área em 2012. Não foi apresentado relatório de NDTs.

A investigação apurou que os fixadores do compensador do estabilizador horizontal (ambas configurações, figura n.º 7) estão sujeitos a cargas e esforços significativos durante todo o voo.

Há ainda a referir que a peça inferior foi identificada na configuração pós modificação SB 53-001 R1 com P/N:116.40.06.033A.

A investigação vai recomendar à EASA para que os fixadores do compensador do estabilizador horizontal (ambas as configurações) tenham um tempo de vida útil até serem redesenhados.

The CAMO states that the last dye-penetrant inspection was done in 2015 as part of a partial overhaul. However, it was only possible to demonstrate an effective inspection to the area on 2012. No NDT report was shown.

The investigation has found that horizontal stabilizer trim attachment fitting (both configurations, figure 7) are subject to substantial loads and forces throughout the flight.

Noted that the lower fitting was identified as Post-Mod SB 53-001 R1 with P/N:116.40.06.033A.

The investigation will recommend to the EASA for horizontal stabilizer trim attachment fitting (both configurations) to be considered as hard-time component until further part redesign assessment.

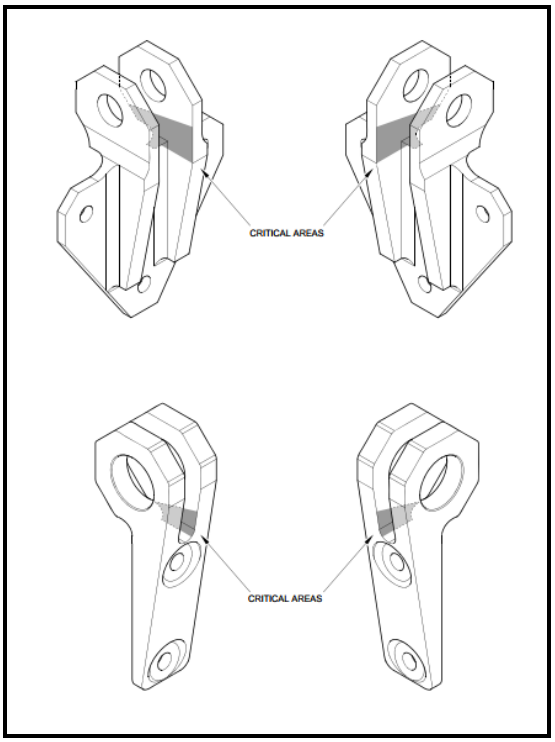


Figura 7 || Figure 7
Fixador do compensador do estabilizador horizontal (ambas configurações) || Horizontal stabilizer trim attachment fitting (both configurations)

1.6.5. Equipamento para paraquedistas || Paradropping equipment

O avião incorporava, entre outros, o "Equipamento opcional" para as operações de paraquedismo, conforme detalhado no suplemento AFM 1824 (Referido na FOCA folha de dados F 56-10 parte 2.96-21 "Equipamento opcional"). A modificação abrange a instalação de um banco longitudinal, uma cadeira, e vários locais para fixação à aeronave.

A ocupação e posicionamento dos paraquedistas e passageiros no voo em que ocorreu o acidente eram como se refere na figura n.º 8.

The airplane incorporated amongst others the "Optional Equipment" for parachutist's operations as detailed in AFM supplement 1824 (Referred to in FOCA data Sheet F 56-10 part 2.96-21 "Optional Equipment"). The modification encompasses the installation of a longitudinal bench, a stool, an external foot step and several guards.

The occupation and positioning of the skydivers and passengers on the flight in which the accident occurred were as referred to in figure n.º 8.

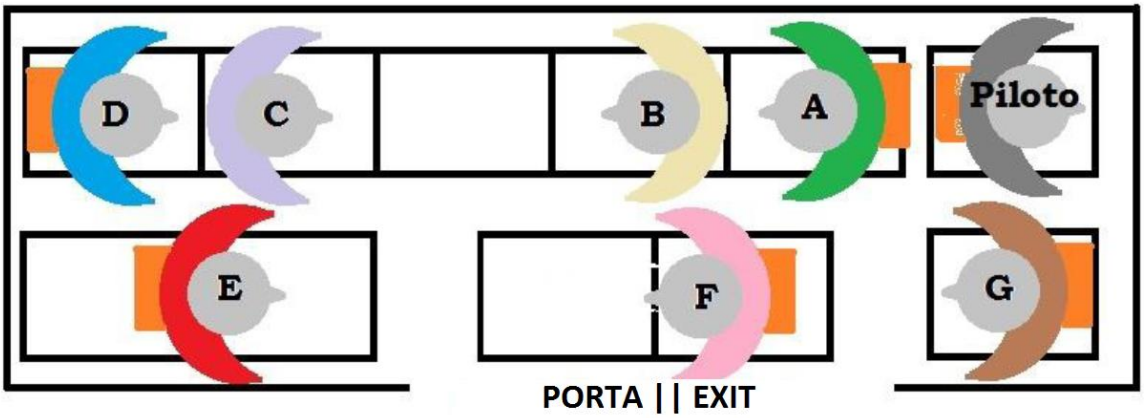


Figura 8 || Figure 8
Esquema de ocupação da aeronave no voo do acidente || Aircraft occupation scheme on the flight of the accident

Legenda:

A – Paraquedista Instrutor *tandem* (ferido)

B – Passageira do Instrutor *tandem* A

D – Paraquedista Instrutor *tandem*

C – Passageiro do Instrutor *tandem* D

G – Paraquedista (ferido)

F – Paraquedista

E – Paraquedista

Legend:

A – Skydiver tandem Instructor (injured)

B – Passenger of the tandem Instructor A

D – Skydiver tandem Instructor

C – Passenger of the tandem Instructor D

G – Skydiver (injured)

F – Skydiver

E – Skydiver

1.6.6. Equipamento de oxigénio || Oxygen equipment

Esta aeronave não estava equipada com um sistema de oxigénio para o piloto ou ocupantes.

O avião voava regularmente até FL 140 e ainda mais alto, embora não estivesse equipado com equipamentos de oxigénio.

This aeroplane was not equipped with a breathing system for pilot or occupants.

The airplane flew regularly up to FL 140 and even higher, although not equipped with oxygen equipment.

O Regulamento aplicável na altura do acidente (Federação Portuguesa de paraquedismo) exigia o uso de equipamentos de oxigénio ao voar acima de FL 150.

The applicable regulation at the time of the accident (Federação Portuguesa de Paraquedismo) required the use of oxygen equipment when flying above FL 150.

1.6.7. Comandos de voo || Flight controls

A aeronave estava equipada com um sistema de comandos de voo convencional para os *ailerons*, leme de profundidade e leme de direção. Roldanas e cabos são usados para operar os comandos de voo. Os comandos de voo primários possuem uma coluna de controlo para o piloto e copiloto para o controlo dos *ailerons* e leme de profundidade e pedais para o leme de direção.

The airplane was equipped with a conventional flight control system for the ailerons, elevators and rudder. Control rods and cables are used to operate the controls. The primary flight controls feature a pilot and a co-pilot control column for the control of the ailerons and elevator and pedals for the rudder.

Cada conjunto de *aileron* tem duas seções juntas no centro. Um contrapeso consistindo num tubo pesado longo é fixado na superfície inferior de cada *aileron* externo. Isso significa que a secção do *aileron* externo é significativamente mais pesada do que a do interior.

Each aileron assembly has two sections joined together at the centre. A counterweight consisting of a long heavy tube is fixed at the lower surface of each outboard aileron. This means that the outboard aileron section is significantly heavier than the inboard one.

Os *ailerons* e o leme de profundidade têm instalado compensadores para reduzir as cargas necessárias para operar esses comandos em voo.

Balance tabs are installed on the ailerons and the elevator to reduce the loads required to operate these controls in flight.

O leme de direção tem um compensador que pode ser ajustável em voo. O estabilizador horizontal é de incidência variável e é usado para o ajuste da razão de subida ou descida da aeronave.

An in-flight adjustable trim tab is installed on the rudder control system. A variable incidence horizontal stabilizer is used for the pitch trim control.

A coluna de comando de voo do copiloto é removível e foi removida nesta aeronave.

The co-pilot control column is removable and was removed for this airplane.

Cada asa possui um conjunto de *flaps*, que se estende da raiz até o meio da asa e consiste em duas seções juntas no centro. Não há interação entre o aileron e os *flaps*.

Each wing features a flap assembly, extending from the wing root up to middle of the wing span and consisting of two sections joined together at the centre. There is no interaction between the aileron and the flaps.

1.6.7.1. Descrição do sistema do compensador do estabilizador horizontal || Horizontal stabilizer trim system description

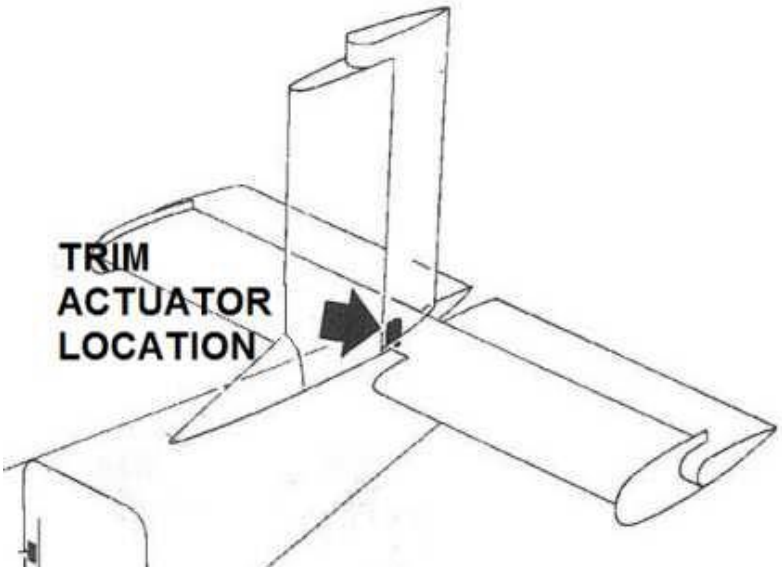


Figura 9 || Figure 9
Localização do compensador || Trim actuator location

O estabilizador está articulado para ambos os lados da fuselagem na zona principal da empenagem, que está aprox. 25% de MAC, permitindo que o bordo de fuga se mova para cima e para baixo sob a ação do atuador do compensador. O atuador está localizado na secção da cauda, na fuselagem, abaixo do estabilizador e permanece estacionário, desde que não seja ativado eletricamente. Quando o piloto opera o interruptor do atuador, o bordo de fuga do estabilizador é movido verticalmente (para cima/para baixo) permitindo uma modificação do ângulo de ataque do estabilizador.

The stabilizer is hinged to both sides of the fuselage at the main spar location, which is at approx. 25% MAC, allowing the trailing edge to move up and down under the action of the pitch trim actuator. The actuator is located in the tail section of the fuselage, below the stabilizer and remains stationary as long as it is not electrically activated. When the pilot operates the actuator trim switch, the trailing edge of the stabilizer is moved vertically (up/down) allowing a modification of the stabilizer's angle of attack.

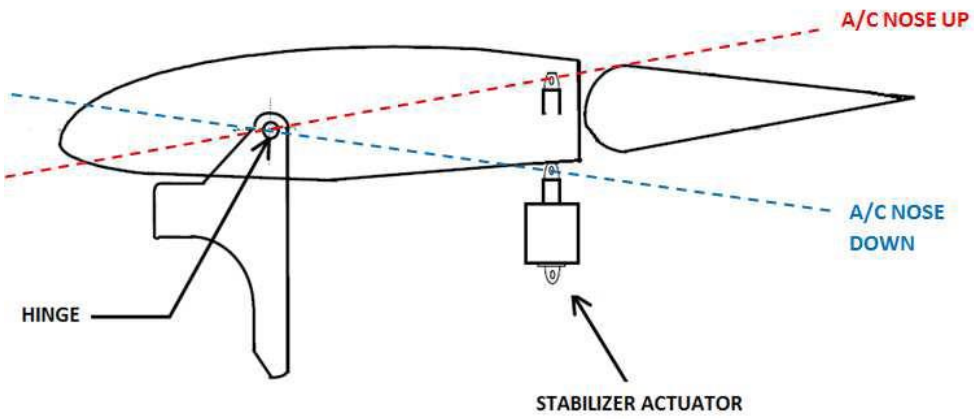


Figura 10 || Figure 10
Desenho do estabilizador horizontal e elevador || Drawing of horizontal stabilizer and elevator

Uma posição retraída do atuador tenderá a colocar a aeronave numa posição de nariz em baixo (bordo de fuga do estabilizador horizontal para baixo) enquanto uma posição estendida do atuador tenderá a colocar a aeronave numa posição de nariz em cima (bordo de fuga do estabilizador horizontal para cima).

O cilindro móvel do atuador do compensador está ligado por um rolamento na extremidade da haste ao lado inferior traseiro do estabilizador, enquanto a extremidade do atuador está ligada à armação da fuselagem por um encaixe de forquilha e um rolamento esférico.

Na posição totalmente retraída eletricamente, o rolamento da extremidade da haste estende-se a 46 mm do invólucro do atuador. O curso completo do atuador é de 85,8 mm.

A retracted position of the actuator will tend to put the aircraft in a nose down position (horizontal stabilizer trailing edge down) while an extended position of the actuator will tend to put the aircraft in a nose up position (horizontal stabilizer trailing edge up).

The movable cylinder of the trim actuator is attached by a rod end bearing to the rear lower side of the stabilizer while the stationary end of the actuator is attached to the fuselage frame by a fork fitting and a spherical bearing.

In the electrically fully retracted position, the rod end bearing extends 46 mm from the actuator casing. The full stroke of the actuator is 85,8 mm.

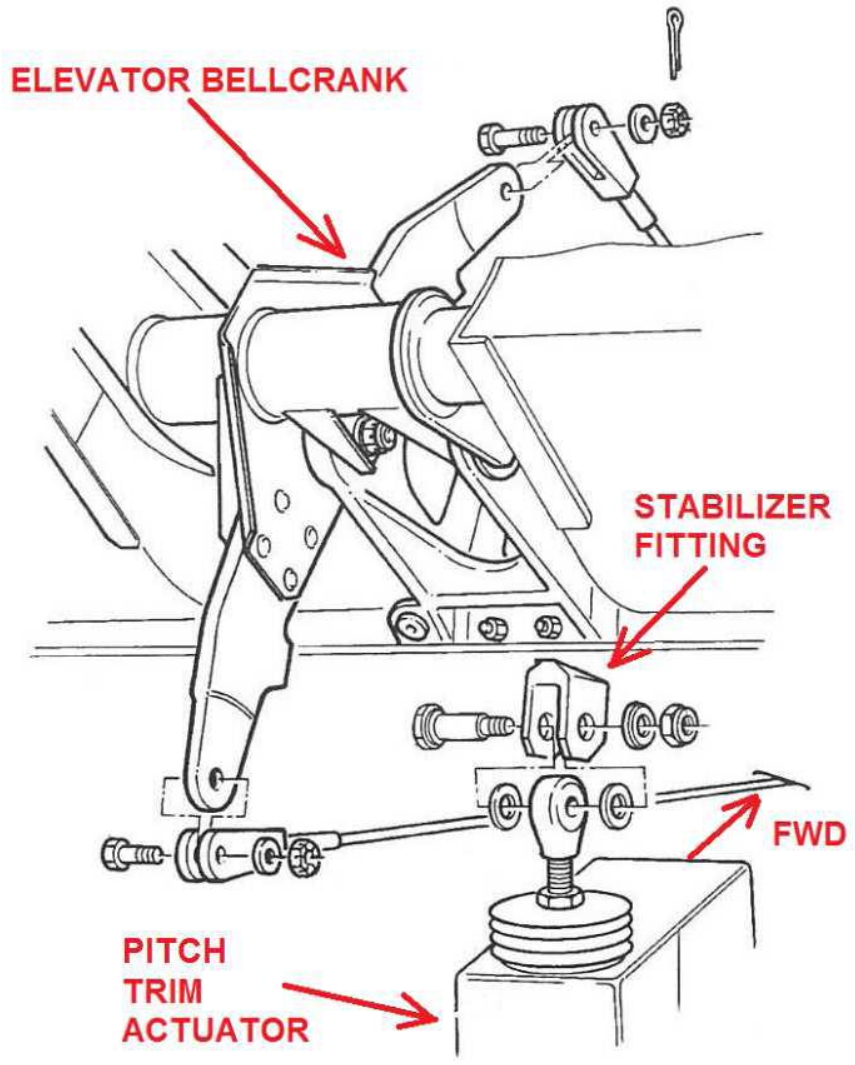


Figura 11 || Figure 11

Desenho do atuador do compensador, bordo de fuga do estabilizador e a alavanca do leme de profundidade|| Drawing of the trim actuator, the stabilizer trailing edge and the elevator bellcrank

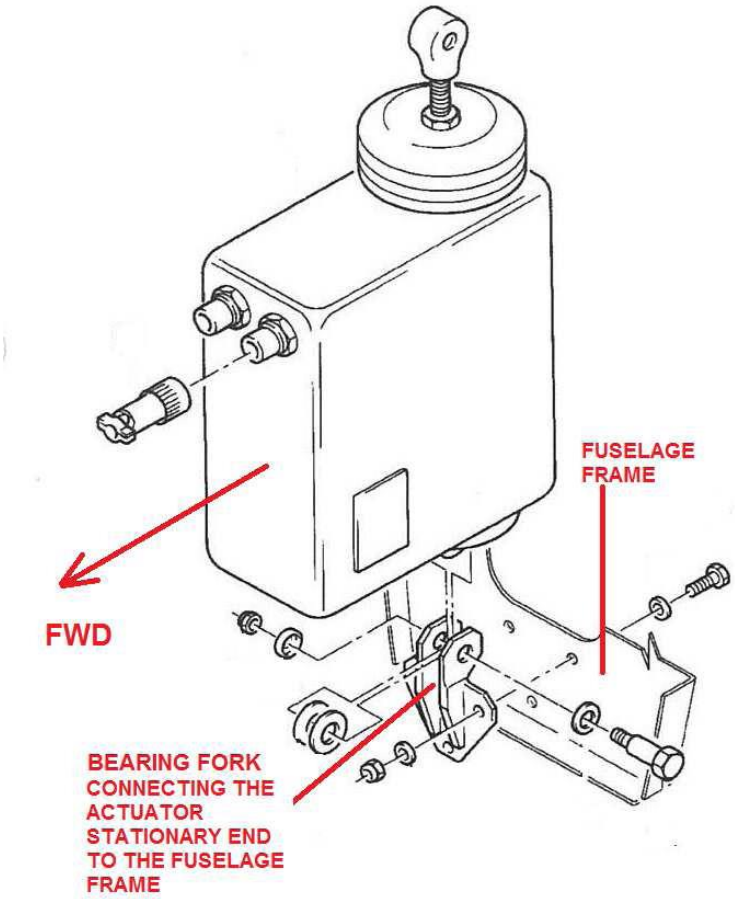


Figura 12 || Figure 12
Instalação do actuador do compensador|| Installation of the trim actuator

Como pode ser visto nas figuras acima, o sistema de compensação do estabilizador do PC-6 B2H4 é totalmente movido eletricamente.

O sistema elétrico do estabilizador horizontal incorpora um atuador linear com motor duplo (um motor para o sistema principal e outro motor para o sistema alternativo).

Um interruptor de três posições com mola é instalado em cada coluna de controlo. O sistema também incorpora dois relés, um para alimentar o motor elétrico em direção ao nariz em cima e outro em direção ao nariz para baixo.

A finalidade do *'INTERRUPT'* (figura n.º 14) é desligar eletricamente o relé "para cima" ou "para baixo" do motor de corte principal. Quando ativado, o relé fornece uma fonte positiva de 28 volt para o enrolamento correspondente do motor do atuador linear.

As can be seen in the figures above, the pitch trim system of the PC-6 B2H4 is fully electrically driven.

The horizontal stabilizer electric system incorporates a dual motor operated linear actuator (One motor for the main and another motor for the alternate system).

A three-position spring loaded trim switch is installed at each control column grip. The system also incorporates two relays, one to feed the electrical motor towards nose up and the other towards the nose down position.

The purpose of the trim switch 'INTERRUPT' (figure n.º 14) is to electrically ground either the "up" or the "down" relay of the main trim motor. When activated, the relay provides a positive 28 volt supply to the corresponding winding of the linear actuator motor.

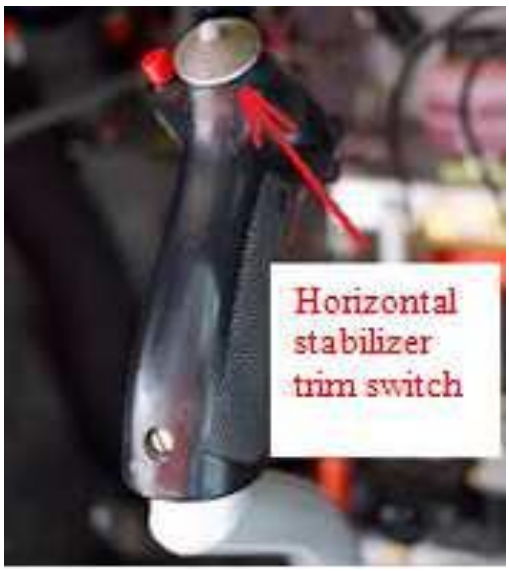


Figura 13 || Figure 13
Imagem de um interruptor semelhante || Picture of a similar stabilizer trim switch

Deve notar-se que demora cerca de 9 segundos para que o atuador se mova, pelo sistema principal, de uma posição neutra até o nariz para cima ou o nariz para baixo (sistema elétrico).

A alimentação de 28 volt do sistema elétrico principal do estabilizador é fornecida através de um interruptor e um disjuntor de 10 A.

Em caso de operação indesejada do compensador, o interruptor localizado no painel de instrumentos deve, quando posicionado na posição de interrupção, desativar os sistemas principal e alternativo.

It has to be noted that it takes about 9 seconds for the actuator to move, by the main system, from a neutral position to the nose up or nose down (electrical) stops.

The 28 volt feed of the stabilizer main electrical system is provided through an interrupt switch and a 10 A circuit breaker.

In case of undesired pitch trim operation, the interrupt switch located on the instrument panel shall, when positioned in the interrupt position, deactivate both the main and the alternate systems.

Figura 14 || Figure 14
Interruptor alternativo do compensador do estabilizador à esquerda e interruptor de paragem à direita || Stabilizer trim alternate switch on the left and interrupt switch on the right

O sistema alternativo pode ser operado depois de se ter retirado manualmente o disjuntor do sistema principal e reposicionado o interruptor *(interrupt)* na posição normal.

The alternate system can be operated after having manually pulled out the circuit breaker of the main system and repositioned the interrupt switch in the normal position.

1.6.8. Variação do fator de carga com velocidade para manobras (Diagrama V-n) || Variation in load factor with airspeed for manoeuvres (V-n Diagram)

O diagrama seguinte (também chamado de envelope estrutural) descreve a combinação permitida de velocidades aéreas e fatores de carga para uma operação segura.

The following diagram (also called structural envelope) describes the allowable combination of airspeeds and load factors for safe operation.

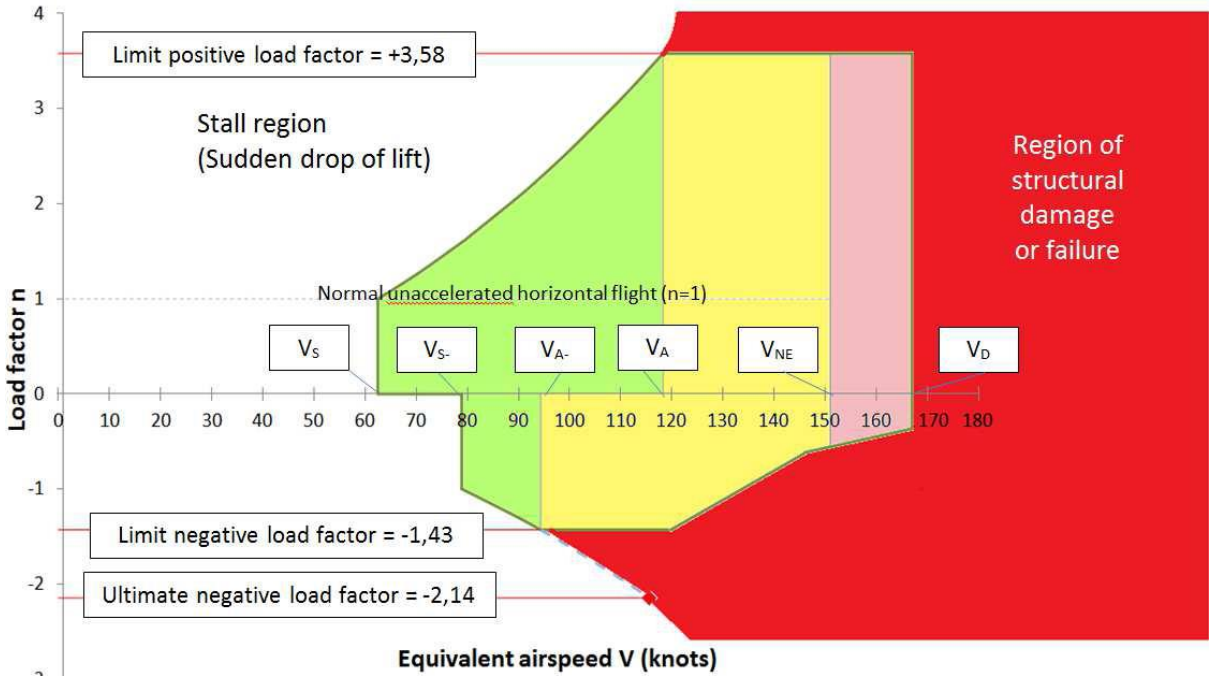


Figura 15 || Figure 15
Diagrama V-n mostrando Velocidade versus Fator de carga || V-n diagram showing Speed versus Load factor

As forças de uma aeronave em operação de voo são apresentadas num gráfico chamado diagrama V-n com a velocidade aerodinâmica (velocidade "V") no eixo X e o fator de carga ("n" ou "g") no eixo Y. Cada modelo de avião tem um diagrama V-n exclusivo definido pelos critérios de certificação e *design* do avião e válido para um determinado peso. Certos pontos no diagrama V-n definem as velocidades operacionais chave, que se destinam a permitir que os pilotos evitem danos estruturais à aeronave devido a cargas de voo excessivas.

The flight operating strength of an airplane is presented on a graph called a V-n diagram with the calibrated airspeed (velocity, "V") in the X-axis and the load factor ("n" or "g") in the Y-axis. Each airplane model has a unique V-n diagram defined by the certification criteria and the airplane design and valid for a given weight. Certain points on the V-n diagram define key operating airspeeds, which are intended to enable pilots to avoid structural damage to the airplane due to excessive flight loads.

Qualquer manobra, rajada ou combinação destas fora do envelope estrutural pode causar danos estruturais ou mesmo falhas e pode efetivamente encurtar a vida útil da aeronave em caso de deformações permanentes.

O diagrama mostra vários limites. A linha horizontal superior é o fator de carga limite positivo. Para o Pilatus PC-6 B2H4, este limite superior é de 3,58, conforme determinado em conformidade com US CAR3. A linha horizontal inferior é o fator de carga limite negativo que, de acordo com as especificações de certificação, é -0,4 vezes o fator de carga positivo (neste caso: -1,43).

A aeronave foi projetada para suportar cargas iguais ao MTOW do avião (2.800 kg) multiplicado pelos fatores de carga limite, fornecidos no diagrama V-n do avião. A aplicação de uma carga acima desses fatores pode causar deformações permanentes na estrutura do avião. A aplicação de uma carga acima do fator de carga final (que é 50% além do fator de carga limite) pode causar a falha da estrutura primária.

O limite vertical no lado direito do diagrama é o limite máximo de velocidade VD. Acima desta velocidade, a deformação e falha da estrutura também pode ocorrer. A velocidade máxima permitida é ajustada em 90% do limite de velocidade (margem de segurança). Essa velocidade é chamada V_{NE}, ou a velocidade para nunca exceder.

A região branca à esquerda do diagrama é limitada pelas chamadas "linhas de perda". Elas representam a velocidade mínima a ser levada a um determinado fator de carga e coeficiente máximo de sustentação. Voar em velocidades inferiores fará com que a aeronave entre em perda e/ou comece a perder altitude. Pode-se observar que as curvas acima e abaixo do eixo X do diagrama V-n não são iguais. Isto é devido ao perfil aerodinâmico assimétrico da asa do PC-6. As velocidades nas quais as curvas cruzam as linhas do limite de carga limitadas são chamadas de velocidades de manobra e, para o caso deste relatório, indicadas como VA (em carga positiva) e VA- (em carga negativa). Estas velocidades são importantes porque, ao voar a velocidades abaixo da velocidade de manobra, a aeronave entra em perda antes de ultrapassar os fatores limite do avião.

Any manoeuvre, gust, or combination thereof outside the structural envelope can cause structural damage or even failure and can effectively shorten the service life of the aircraft if permanent deformation occurs.

The diagram shows various boundaries. The upper horizontal line is the positive limit load factor. For the Pilatus PC-6 B2H4 this upper limit is 3,58 as determined in compliance with US CAR3. The lower horizontal line is the negative limit load factor which, according to the certification specifications, is -0.4 times the positive load factor (in this case: -1,43).

The aircraft is designed to withstand loads equal to the airplane's MTOW (2.800 kg) multiplied by the limit load factors, provided in the V-n diagram of the airplane. Applying a load above these factors may cause permanent deformations to the airplane's structure. Applying a load above the ultimate load factor (which is 50% beyond the limit load factor) may cause the failure of the primary structure.

The vertical boundary at the right side of the diagram is the maximum speed limit VD. Above this speed, deformation and failure of the structure may also occur. The maximum allowed airspeed is set at 90% of the speed limit (safety margin). This speed is called V_{NE}, or the velocity to never exceed.

The white region on the left of the diagram is edged by the so-called "stall lines". They represent the minimum speed to be flown at a given load factor and maximum lift coefficient. Flying at lower airspeeds will cause the aircraft to stall and/or start to descend. It can be observed that the curves above and below the X-axis of the V-n diagram are not equal. This is due to the asymmetric airfoil of the PC-6 wing. The speeds where the curves intersect the limit load factor lines are called the manoeuvring speeds and for the sake of this report indicated as VA (in positive load) and VA- (in negative load). These speeds are important because when flying at speeds below the manoeuvring speed, the aircraft will always stall before exceeding the airplane's limit factors.

Ao voar a velocidades mais altas (zona amarela no diagrama), devem ser evitados movimentos de controlo abruptos ou voar em condições turbulentas para evitar superar os fatores limite.

Foi calculado para uma aeronave do mesmo tipo PC-6, que esta permanecerá dentro do envelope e suportará condições de rajada de +30 e -30 fps num voo normal não acelerado (o fator de carga é igual a +1). Pode-se observar que a zona amarela começa a uma velocidade menor quando submetida a cargas negativas (94 kt *vs.* 119 kt), o que significa que a carga limite será alcançada antes. Ao extrapolar a linha de perda negativa, a velocidade na qual o fator de carga final negativo é alcançado pode ser determinada em torno de 115 kt.

When flying at higher speeds (yellow zone in the diagram), abrupt control inputs or flying in turbulent conditions should be avoided to prevent exceeding the limit factors.

It has been calculated for a similar PC-6, that it will stay within the envelope and withstand gust conditions of +30 and -30 fps in a normal un-accelerated flight (the load factor equals +1). It can be observed that the yellow zone starts at a lower speed when submitted to negative loads (94 kt versus 119 kt) which means that the limit load will be reached earlier. When extrapolating the negative stall line, the speed at which the negative ultimate load factor is reached can be determined around 115 kt.

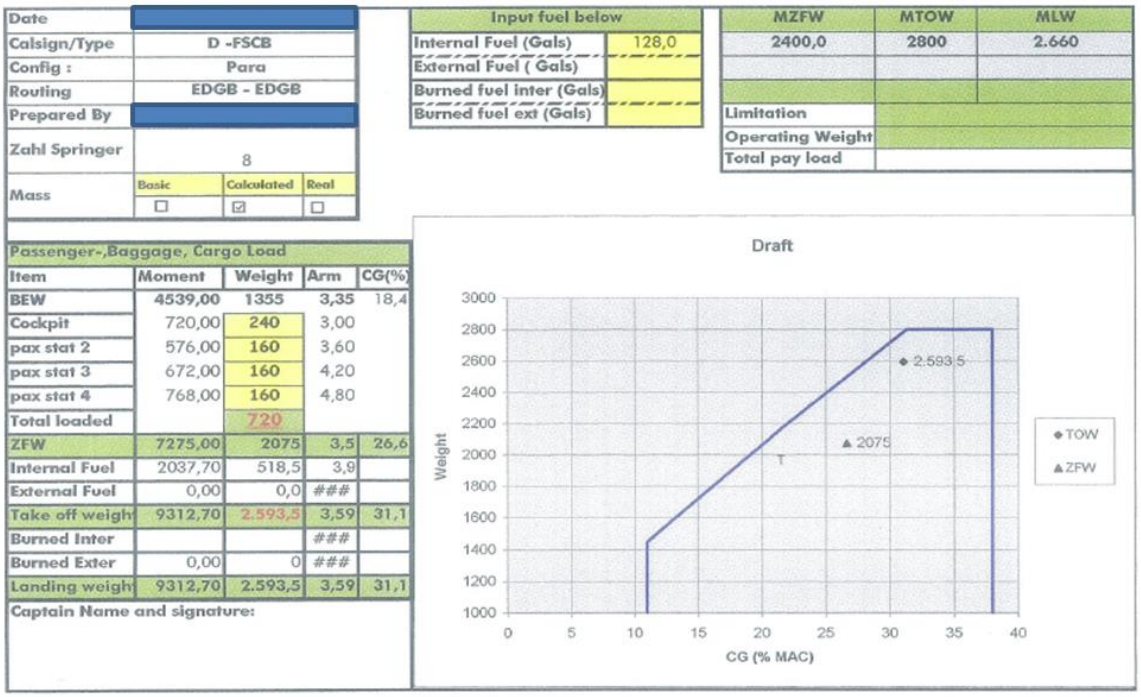
1.6.9. Massa e Centragem || Weight and Balance

A aeronave foi pesada pela última vez em 21 de março de 2014 na seguinte configuração: com o óleo completo do motor, o combustível inutilizável e o equipamento específico para o lançamento do paraquedismo instalado.

O piloto tinha vários modelos pré-preenchidos de acordo com as diversas configurações de paraquedistas e de combustível.

The airplane was last weighed on 21 March 2014 in the following configuration: With full engine oil, unusable fuel and the specific equipment for parachutist dropping installed.

The pilot had several pre-filled models according to the various configurations of paratroopers and fuel.



Date	
Calsign/Type	D -FSCB
Config :	Para
Routing	EDGB - EDGB
Prepared By	
Zahl Springer	8
Mass	Basic ☐ Calculated ☑ Real ☐

Input fuel below	
Internal Fuel (Gals)	128,0
External Fuel (Gals)	
Burned fuel inter (Gals)	
Burned fuel ext (Gals)	

MZFW	MTOW	MLW
2400,0	2800	2.660
Limitation		
Operating Weight		
Total pay load		

Passenger-,Baggage, Cargo Load

Item	Moment	Weight	Arm	CG(%)
BEW	4539,00	1355	3,35	18,4
Cockpit	720,00	240	3,00	
pax stat 2	576,00	160	3,60	
pax stat 3	672,00	160	4,20	
pax stat 4	768,00	160	4,80	
Total loaded		720		
ZFW	7275,00	2075	3,5	26,6
Internal Fuel	2037,70	518,5	3,9	
External Fuel	0,00	0,0	###	
Take off weigh	9312,70	2.593,5	3,59	31,1
Burned Inter			###	
Burned Exter	0,00	0	###	
Landing weigh	9312,70	2.593,5	3,59	31,1

Captain Name and signature:

Figura 16 || Figure 16
Folha de carga || Load sheet

O cálculo acima mostra que o CG estava dentro do limite do envelope CG do avião (o limite *Fwd* é 28% e o limite *Aft* é de 38% do envelope CG). Além disso, o peso do avião estava dentro dos limites (MTOW é de 2.800 kg).

The above computation shows that the CG was within limit of the CG envelope of the airplane (Fwd limit is 28% and Aft limit is 38% from the CG envelope). Furthermore, the weight of the airplane was within limits (MTOW is 2.800 kg).

1.7. Informação meteorológica || Meteorological conditions

As condições meteorológicas locais eram VMC, com o céu limpo. O vento 10 nós e a pressão local era de 1022 hPa. A visibilidade era superior a 10 km, a temperatura do ar era de 32° C.

A estação meteorológica com informação aeronáutica mais próxima era Beja (LPBJ) a cerca de 15 NM (27 km) do local do acidente, tendo sido obtidos os seguintes METAR:

The local weather conditions were VMC, with clear sky. The wind intensity of 10 Knots and the local pressure was 1022 hPa. The visibility was over 10 km, the air temperature was 32° C.

The nearest meteorological station with aeronautical information was Beja (LPBJ) about 15 NM (27 km) from the crash site, from which the following METAR were obtained:

LPBJ, Beja (Portugal).
WMO index: 08562. Latitude 38-01N. Longitude 007-52W. Altitude 246 m.

METAR/SPECI from LPBJ, Beja (Portugal).

SA 19/06/2016 21:30->	METAR LPBJ 192130Z NIL=
SA 19/06/2016 21:00->	METAR LPBJ 192100Z 35008KT CAVOK 26/05 Q1023=
SA 19/06/2016 20:30->	METAR LPBJ 192030Z NIL=
SA 19/06/2016 20:00->	METAR LPBJ 192000Z 35008KT CAVOK 28/04 Q1022=
SA 19/06/2016 19:30->	METAR LPBJ 191930Z NIL=
SA 19/06/2016 19:00->	METAR LPBJ 191900Z 03010KT CAVOK 31/02 Q1022=
SA 19/06/2016 18:30->	METAR LPBJ 191830Z NIL=
SA 19/06/2016 18:00->	METAR LPBJ 191800Z 04010KT 010V070 CAVOK 32/02 Q1022=
SA 19/06/2016 17:30->	METAR LPBJ 191730Z NIL=
SA 19/06/2016 17:00->	METAR LPBJ 191700Z 04010KT CAVOK 33/01 Q1022=

Figura 17 || Figure 17
METAR de Beja (LPBJ) || Beja METAR (LPBJ)

1.8. Ajudas à navegação || Aids to navigation

O aeródromo LPFC está localizado na TRA 13.

Qualquer atividade só poderá ter lugar quando a LP-TRA 13 não estiver ativa.

Qualquer operação aérea carece de prévia coordenação com Lisboa Militar.

The LPFC airfield being located at TRA 13.

Any activity can only take place when LP-TRA 13 is not active.

Operation subject to previous coordination with Lisboa Militar.

1.9. Comunicações || Communications

A aeronave estava equipada com comunicações bilaterais em VHF e *transponder*.

The aircraft was equipped with two-way VHF communications and transponder.

1.10. Informação do aeródromo || Aerodrome information

O acidente ocorreu a uma distância de cerca de 6 km a oeste-sudoeste do aeródromo de LPFC.

O aeródromo está equipado com uma pista de aterragem de asfalto 17/35 bidirecional. As dimensões da pista são 660 m x 18 m.

É necessária autorização prévia do diretor para o uso do aeródromo.

The crash occurred at a distance of about 6 kilometres west-southwest of the LPFC airfield.

The airfield is equipped with an asphalt runway 17/35 bi-directional runway. The dimensions of runway is 660 m x 18 m.

Prior permission is required from the AD director for the use of the airfield.

Figura 18 || Figure 18
Aeródromo de Figueira de Cavaleiros (LPFC) || Aerodrome of Figueira de Cavaleiros (LPFC)

1.10.1. Visão do espaço aéreo acima LPFC || Airspace view above LPFC

A figura seguinte mostra a acumulação das diferentes áreas controladas e não controladas acima do aeródromo de Figueira de Cavaleiros

The following drawing shows the build-up of the different controlled and uncontrolled areas above Figueira de Cavaleiros airfield.

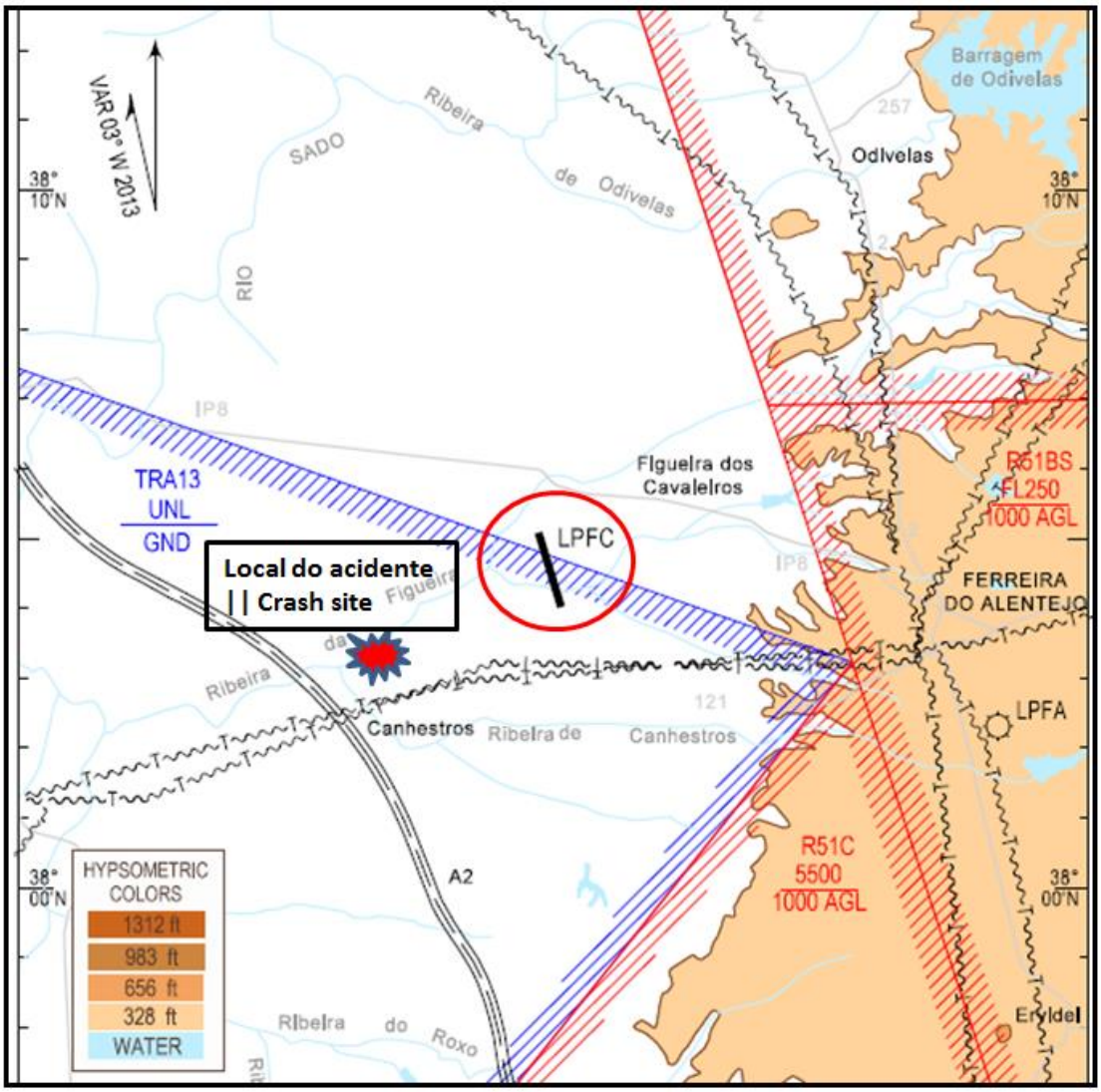


Figura 19 || Figure 19
Posição relativa da TRA 13, LPFC e local do acidente || Relative position of TRA 13, LPFC and crash site

1.10.1.1. Aviso à Navegação || NOTAM

1. Diariamente SR - SS, ocorrerão exercícios de paraquedismo numa área definida por um círculo com 3NM de raio centrado em 380429N 0081404W (Figueira de Cavaleiros AD - LPFC) e com os limites verticais SFC/FL240. Qualquer atividade só poderá ter lugar quando a área LP-TRA13 não estiver ativa. Qualquer operação aérea carece de prévia coordenação com Lisboa Militar e acima de FL095 cada voo terá de ser coordenado com o órgão ATS. A aprovação ficará sujeita ao tráfego existente.

2. Validade: De 13-NOV-2015 a 31-DEC-2016, fim de validade estimado.

1. Daily SR - SS, parachute jumping exercises will take place on area defined by a circle with 3NM radius centred at 380429N 0081404W (Figueira de Cavaleiros AD - LPFC) and with vertical limits SFC/FL240. Any activity can only take place when LP-TRA13 is not active. Operation subject to previous coordination with Lisboa Militar and above FL095 each flight must be coordinated with ATS provider. Approval will be subject to traffic.

2. Validity: From 13-NOV-2015 with expecting end date of 31-DEC-2016.

3. Esta atividade será imediatamente cancelada caso o Operador não mantenha as devidas licenças/autorizações válidas.

3. This activity shall be immediately cancelled if the operator does not hold the appropriate Licenses/Permits valid.

1.11. Gravadores de voo || Flight recorders

A aeronave não estava equipada com um gravador de registo de dados de voo, nem era um requisito.

The aeroplane was not equipped with a flight recorder, nor was it a requirement.

Câmaras de gravação foram levadas por alguns paraquedistas. Apenas uma câmara foi encontrada no meio dos destroços da cauda da aeronave. A câmara foi examinada pelo GPIAAF, mas apenas registou a fase de descolagem, o que é normal porque normalmente só são utilizadas durante o salto.

Action cameras were carried by some skydivers. Only one camera was found in the middle of the tail of the aircraft wreckage. The camera was examined by the GPIAAF, but only recorded the takeoff phase, which is not abnormal as they would normally only be used during the jump.

Todos os paraquedas de reserva estavam equipados com um dispositivo de ativação automática (AAD).

All emergency parachutes were equipped with an Automatic Activation Device (AAD).

O gráfico de um dos paraquedistas inicia à altitude de cerca de 1.900 metros. Começa com uma velocidade vertical calma de aproximadamente 59 m/s nos primeiros 4 segundos. Em seguida, vemos uma flutuação de pressão do ar muito severa entre a altitude de cerca de 1.680 m e 1.370 metros. A velocidade vertical restante é muito acidentada e mostra uma série de irregularidades na pressão do ar. Alivia a cerca de 4 segundos antes da ativação, que teve lugar na altitude de aproximadamente 243 metros devido a velocidade vertical de aproximadamente 58 m/s. A velocidade vertical diminuiu significativamente na altitude de aproximadamente 160 metros para valores de aproximadamente 5 m/s.

The graph of one of the skydivers starts at the altitude of approximately 1.900 meters. It starts out with a calm vertical speed of approximately 59 m/s for the first 4 seconds. Then we see a very severe air-pressure fluctuation between the altitude of approximately 1.680 m and 1.370 meters. The remaining vertical speed is very bumpy and shows a lot of irregularities in air-pressure. It eases about 4 seconds prior to the activation which took place at the altitude of approximately 243 meter due to the vertical speed of approximately 58 m/s. The vertical speed decreased significantly at the altitude of approximately 160 meters to values of approximately 5 m/s.

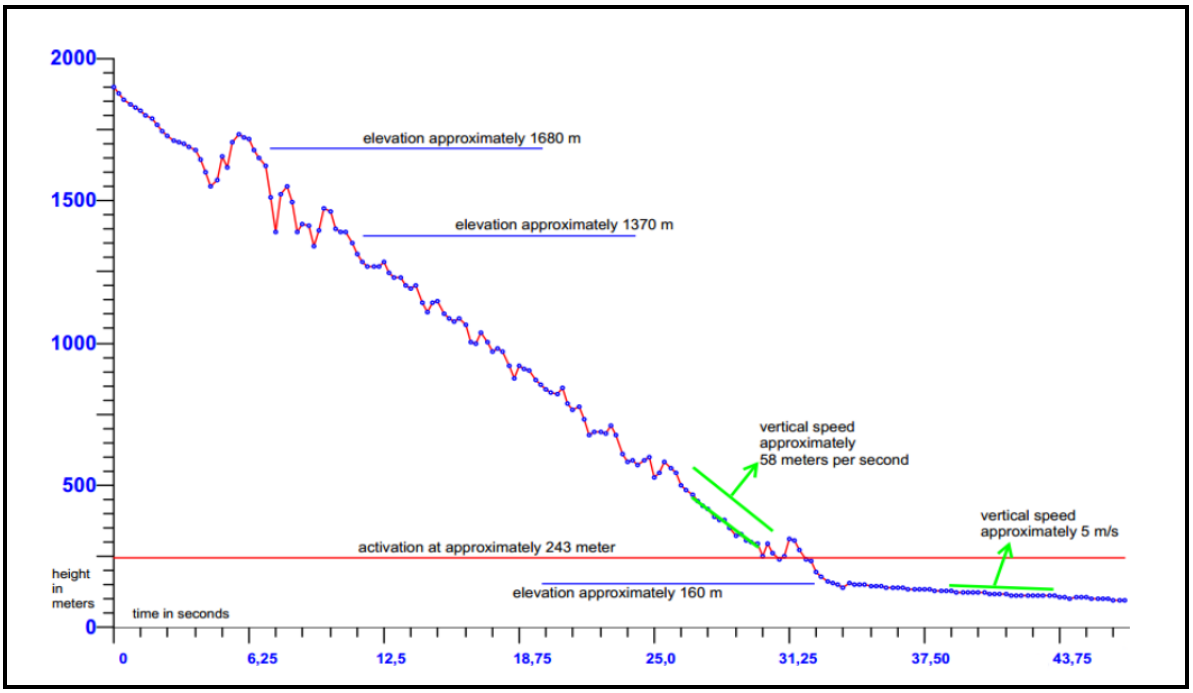


Figura 20 || Figure 20
Gravador de altitudes do sistema automático de abertura dos paraquedas || AAD's record

1.12. Destroços e informação sobre os impactos || Wreckage and impact information

A aeronave desintegrou-se em voo, tendo os destroços caído numa extensão de aproximadamente 1.500 metros numa faixa de cerca de 500 metros e estavam muito dispersos, apresentando um alinhamento com a direção do voo, de oeste para leste num campo localizado a norte da aldeia de Canhestros.

The airplane disintegrated in flight, with the wreckage falling to an extent of approximately 1.500 meters in a range of about 500 meters and were widely scattered, aligning with the direction of the flight, from west to east in a field located north of the village of Canhestros.

Figura 21 || Figure 21
A hélice, o motor e a secção do nariz|| The propeller, the engine and the nose section

A empenagem e fuselagem da aeronave foram uma das últimas secções a ser localizada, pois encontrava-se a cerca de 500 m do motor numa zona com muita e alta vegetação.

The empennage and fuselage of the aircraft were one of the last sections to be located, because they were distanced about 500 m of the engine in an area with a lot of high vegetation.

Figura 22 || Figure 22
A empenagem e fuselagem|| The empennage and fuselage

1.12.1. Exame detalhado dos destroços || Detailed examination of the wreckage

Os destroços da aeronave foram inspecionados no hangar da Autoridade de Investigação em Viseu/Portugal em 5 de julho de 2016, pelo STSB, pela Empa e pela Pilatus, em coordenação com a investigação.

The wreck of the aircraft was inspected in the hangar of the SIA in Viseu/Portugal on July 5th, 2016 by STSB, Empa and Pilatus, in coordination with the investigation.

As partes principais dos destroços que foram recuperados separadamente foram:

The main parts of the wreckage that were separately recovered were:

- Chapa para-fogo com motor;
- Cockpit/fuselagem até aproximadamente a raiz da asa;
- Secção da fuselagem traseira, incluindo cauda / leme vertical e estabilizador horizontal direito / e leme de profundidade direito;
- Estrutura da asa direita (em 2 partes), todas as 4 superfícies de controlo (2 *ailerons*, incluindo o peso de balanceamento no *aileron* externo, 2 *flaps*) e a ponta da asa;
- Estrutura de asa esquerda (em 2 partes), todas as 4 superfícies de controlo (incluindo o peso balanceado do *aileron*) e a ponta da asa;
- Estabilizador horizontal esquerdo;
- Partes do leme de profundidade esquerdo.

- Firewall with engine;
- Cockpit/fuselage section up to approx. main wing spar
- Rear fuselage section including vertical tail/rudder and right horizontal stabilizer/right elevator;
- Right wing structure (in 2 parts), all 4 control surfaces (2 ailerons including balancing weight at outboard aileron, 2 flaps) and wing tip;
- Left wing structure (in 2 parts), all 4 control surfaces (including aileron balancing weight) and wing tip
- Left horizontal stabilizer;
- Parts of the left elevator.

1.12.1.1. Continuidade dos comandos de voo || Flight control continuity

A continuidade do controlo do *aileron* foi confirmada em todo o caminho desde o comando até às superfícies do *aileron*.

The continuity of the aileron control was confirmed all the way from the control stick to the aileron surfaces.

A continuidade do controlo do leme de profundidade foi confirmada desde o comando até a superfície do leme de profundidade.

The continuity of the elevator control was confirmed all the way from the control stick to the elevator surface.

A continuidade do controlo do leme de direção foi confirmada a partir dos pedais no cockpit até à superfície do leme.

The continuity of the rudder control was confirmed from the rudder pedals to the rudder surface.

Figura 23 || Figure 23
Asa esquerda || Left wing

Figura 24 || Figure 24
Asa direita || Right wing

1.12.1.2. Estabilizador horizontal || Horizontal stabilizer

As partes central e direita do estabilizador horizontal (HT) foram dobradas e amassadas, mas estavam parcialmente ligadas à empenagem. O leme de profundidade direito estava conectado ao HT pela dobradiça do leme de profundidade e pelo suporte de fixação central com a haste de controlo para os cabos de controlo do leme de profundidade. O servo-guia direito do compensador estava ligado e o leme de profundidade e a barra de pressão da superfície estavam no lugar.

The center and right part of the horizontal stabilizer (HT) were bent and dented, but still partially attached to the empennage. The right elevator was connected to the HT by the elevator hinge and by the center attachment bracket with the control horn for the elevator control cables. The right Flettner-servo-tab was attached and the elevator and the push-pull-rod of the Flettner-tab were in place.

Os dois suportes de fixação dianteiros do estabilizador horizontal estavam fixados no suporte dianteiro do estabilizador horizontal (parte central e direita do HT) e os parafusos estavam intactos. Os suportes de fixação foram parcialmente arrancados da fuselagem.

The two forward attachment brackets of the horizontal stabilizer were attached to the front spar of the horizontal stabilizer (center and right part of the HT) and the bolts were intact. The attachment brackets were partially torn off the fuselage.

O atuador do compensador do estabilizador horizontal ainda estava conectado à parte traseira do estabilizador horizontal. Contudo, a ligação inferior do atuador do compensador do estabilizador horizontal que se conecta à estrutura da fuselagem estava partida.

The horizontal stabilizer trim actuator was still attached to the rear spar of the horizontal stabilizer. However the lower attachment of the horizontal stabilizer trim actuator that connects to the fuselage structure had failed.

O estabilizador horizontal esquerdo separou da empenagem. As pontas das longarinas principais da cauda estavam torcidas ao longo do eixo de torção em cerca de 180 ° (momento de torção direta) e dobradas para trás em cerca de 90 °.

The left horizontal stabilizer had separated from the empennage. The horizontal tail main spar caps were twisted along the torsional axis by about 180° (forward torsional moment) and bent backwards by about 90°.

Foram encontrados dois pedaços muito danificados do leme de profundidade esquerdo.

Two heavily damaged pieces of the left elevator were found.

O compensador esquerdo não foi encontrado. O tirante do compensador ainda estava conectado ao estabilizador horizontal, mas o rolamento esférico no final estava ausente, sem sinais de ter partido.

The left Flettner-servo-tab was not found. The push-pull-rod of the Flettner-servo-tab was found still connected to the horizontal tail, but the ball joint at its end was missing, but didn’t broke off.

Figura 25 || Figure 25
Estabilizador horizontal || Horizontal stabilizer

1.12.1.3. Fixação do actuador do compensador ao avião || A/C sided HT-trim actuator fitting

O acessório de fixação do atuador do compensador HT foi encontrado quebrado na conexão do atuador à fuselagem (Figura 26 e 27). Visualmente, as superfícies fraturadas estavam parcialmente pretas (gordurosas). Para uma investigação mais aprofundada, os fragmentos do lado do atuador foram enviados à Empa para observações com um microscópio eletrónico de varredura, com alta ampliação (apêndice 1).

The HT-trim attachment fitting was found broken at the connection to the trim actuator (Figure 26 and 27). Visually, the fractured surfaces appeared partially black (greasy). For a closer investigation, the actuator-sided fragments were sent to Empa for a observations with a scanning electron microscope, at high magnification (appendix 1).

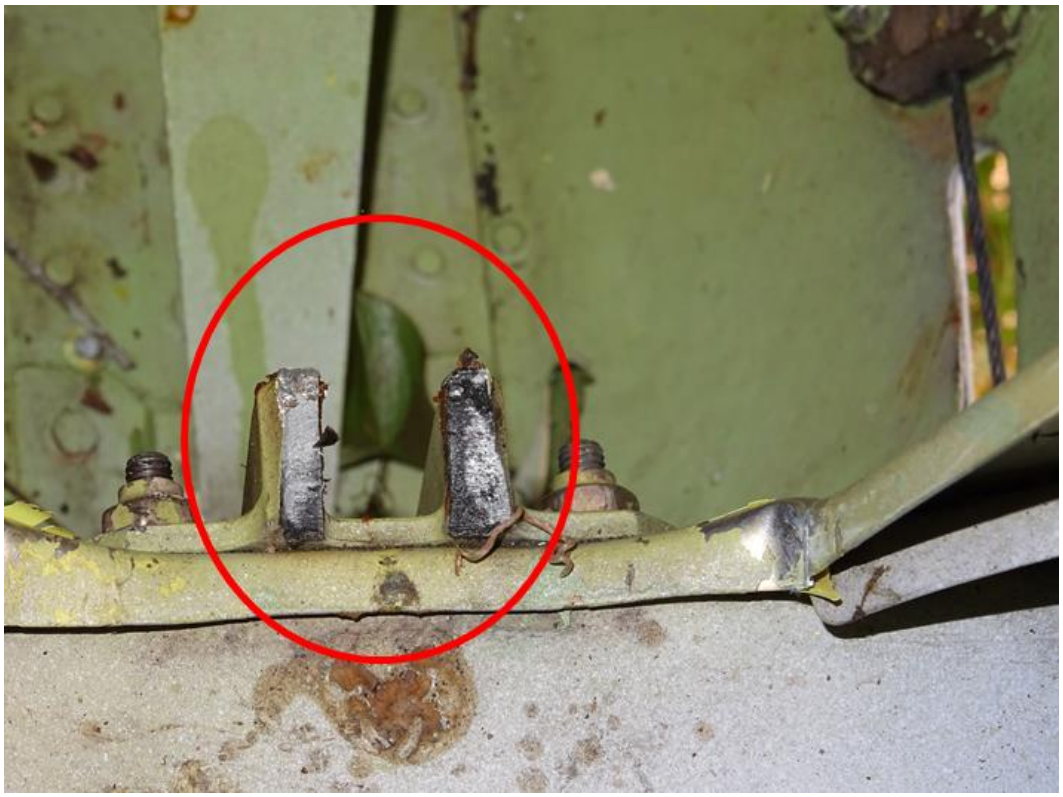


Figura 26 || Figure 26
Fixação do atuador do compensador || Trim actuator fitting

Figura 27 || Figure 27
Fixação do actuador do compensador || Trim actuator fitting

1.13. Informação médica e patológica || Medical and pathological information

As informações médicas sobre o piloto não apresentaram fatores fisiológicos que possam ter contribuído para as circunstâncias deste acidente.

Medical information about the pilot did not present physiological factors that may have contributed to the circumstances of this accident.

Conclui-se com base na autópsia realizada pelos médicos de medicina legal, que o piloto morreu devido a lesões traumáticas compatíveis com ação de natureza contundente na região craniana, torácica e abdominal.

It is concluded on the basis of an autopsy performed by doctors of legal medicine that the pilot died due to traumatic injuries compatible with action of a blunt nature in the cranial, thoracic and abdominal region.

Não foram encontrados vestígios de álcool nem substâncias estupefacientes ou psicotrópicas.

No traces of alcohol or narcotics or psychotropic substances were found.

1.14. Fogo || Fire

Não houve incendio.

There was no fire.

1.15. Aspetos de sobrevivência || Survival aspects

Todos os instrutores de salto usavam um paraquedas principal e um paraquedas de emergência, que dispunham de dispositivos de abertura automática, constituídos por uma unidade de controlo que ligava o dispositivo e era usada para fazer os ajustes necessários.

All of the jump instructors were wearing both a main and an emergency parachute, which had automatic deployment devices consisting of a control unit that turned on the device and was used to make the necessary adjustments.

Dois dos passageiros estavam saltando em tandem ligados aos instrutores através de um arnês que os mantinha presos um ao outro durante o salto.

Two of the passengers were jumping in tandem attached to their instructors via a harness that kept them attached to each other during the jump.

O assento do piloto estava equipado com cintos de segurança (incorporando cintos na cintura e nos ombros). O piloto também estava equipado com um paraquedas de abertura manual.

The pilot seat was equipped with safety belts, (incorporating lap and shoulder harness). The pilot was also equipped with a manual opening parachute.

O paraquedas do piloto não abriu, porque não estava equipado com o sistema de segurança que os paraquedas dos outros ocupantes tinham.

The pilot's parachute didn't deploy because it was not equipped with the safety system that the other occupants' parachutes had.

Devido à desintegração da aeronave em voo e ao local onde foi encontrado o corpo do piloto presume-se que o piloto tentou abandonar a cabine da aeronave depois de todos os paraquedistas terem saltado, mas devido à instabilidade do voo terá batido com a cabeça e

Due to the disintegration of the aircraft in flight and the place where the body of the pilot was found, it is assumed that the pilot tried to leave the cabin of the aircraft after all the skydivers had jumped, but due to the instability of the flight he would have hit his head, loosing

perdido os sentidos, não conseguindo abrir o seu paraquedas.

consciousness and failing to open his parachute.

A violência do impacto final não permitiu a sobrevivência do piloto da aeronave.

The violence of the final impact was not survivable for the pilot of the airplane.

O sistema nacional de emergência foi ativado às 18:20 UTC. Estiveram envolvidos, nesta operação de socorro, 56 operacionais, 22 veículos e um helicóptero do Instituto Nacional de Emergência Médica (INEM).

The national emergency system was activated at 18:20 UTC. A team of fifty-six elements, 22 vehicles and one helicopter of the National Institute of Medical Emergency (INEM) were involved in this rescue operation.

1.16. Ensaios e Pesquisas || Tests and Research

As investigações iniciais indicaram uma necessidade potencial de uma investigação de fractografia de certas partes. A STSB envolveu a Empa para cumprir esta tarefa Uma inspeção dos destroços ocorreu em 5 de Julho de 2016 em Viseu, Portugal (STSB, Pilatus, GPIAAF, Empa). Durante a inspeção, alguns fragmentos dos destroços foram levados para a EMPA para investigação, que serão descritos nos apêndices N. 1 e 2 do presente relatório.

The initial investigations indicated a potential need for a fractography investigation of certain parts. The STSB involved Empa to fulfill this task. An inspection of the wreckage took place on July 5th, 2016 in Viseu, Portugal (STSB, Pilatus, GPIAAF, Empa). During the inspection certain fragments from the wreckage were taken to EMPA for investigation, which will be described enclosed in the appendixes N. 1 and 2 to this report.

As observações do acessório de fixação do compensador HT com um microscópio eletrónico de varredura, com alta ampliação, mostraram que ambas as superfícies fraturadas (RH e LH) apresentavam fissuras significativas por fadiga. As fendas de fadiga começaram em vários lugares, o que significa que não há uma única origem de fenda. Enquanto a fenda de fadiga na fratura de RH quase separou a secção transversal completa, a fratura de LH mostra uma parcela significativa da fratura de sobrecarga dúctil (rutura final).

The HT-trim attachment fitting observations with a scanning electron microscope, at high magnification, showed that both fractured surfaces (RH and LH) had significant fatigue cracking. The fatigue cracks started at multiple places, meaning there is not one single crack origin. While the fatigue crack on the RH fracture almost separated the complete cross-section, the LH fracture shows a significant portion of ductile overload fracture (final rupture).

Devido à potencial relevância dos factos, foi conduzida uma investigação mais aprofundada em coordenação com o STSB e o fabricante Pilatus Aircraft.

Because of the potential relevance of this finding, a deep investigations have been initiated in coordination with the STSB and Pilatus Aircraft.

As fraturas classificadas de fadiga cíclica elevada (HFC) detetadas em ambas as abas, esquerda e direita, apresentaram um ponto específico de início de fratura, ao contrário do anteriormente referido de origens múltiplas. No apêndice N.4 ao presente relatório pode ser consultada a última versão do estudo da EMPA.

The fractures can be classified as a typical high cycle fatigue (HCF) fractures. It appears that the fatigue crack, both at the LH and RH fractures started at a specific point, not as initially reported at multiple points. Please see appendix N. 4 with the latest version of the EMPA report.

A rutura da fuselagem foi inspecionada

The ruptured fuselage has been visually

visualmente durante os trabalhos no hangar em Viseu, Portugal. Como é difícil diferenciar entre fratura dúctil/fadiga e o comportamento de rutura frágil de certas ligas de alumínio somente a olho, foi decidido investigar mais profundamente algumas partes da fuselagem rasgada. Um total de três segmentos de fuselagem foi investigado na Empa (descrito no apêndice N. 2 deste relatório.

inspected during the visit at the hangar in Viseu, Portugal. As it is difficult to differentiate between the ductile/fatigue and brittle failure behavior of certain aluminum alloys by eye only, it was decided to closer investigate certain parts of the ruptured fuselage. A total of three fuselage segments were investigated at Empa (appendix N. 2 to this report).

Verificou-se que as superfícies fraturadas da fuselagem investigadas mostram apenas fratura dúctil de sobrecarga. Não foi encontrado nenhum pré-dano ou indicação de um crescimento lento e progressivo da fenda. A falha na secção de fuselagem investigada pode ser vista como "dano secundário" durante a sequência de eventos.

It has been found that the fracture surfaces of the fuselage investigated only show ductile overload fracture. No pre-damage or indication of a slow progressing crack growth could be found. The failure of the investigated fuselage section can be seen as “secondary damage” during the sequence of events.

1.17. Organização e gestão || Organizational and management information

O Grupo 7Air, era detentor da empresa de paraquedismo *Skyfall*, que organizava os saltos e a aeronave acidentada, era propriedade particular.

The 7Air Group, which owned the Skyfall skydiving company, which organized the jumps and the crashed aircraft, was privately owned.

O operador tinha uma autorização da ANAC, para a livre prestação de serviços de trabalho aéreo na modalidade de lançamento de paraquedistas, em espaço aéreo sob jurisdição nacional.

The operator had an authorization from ANAC for the unrestricted provision of air work services in the form of launching parachutists in airspace under national jurisdiction.

1.18. Informação adicional || Additional information

1.18.1 Acidentes com aeronaves de largada de paraquedistas, no período 1987-2014 || About parachuting aeroplanes’ accidents, period 1987-2014

Os bancos de dados de várias Autoridades de Investigação de Segurança, nomeadamente a AAIU Belga, foram pesquisados em relação a ocorrência de acidentes envolvendo voos de largada de paraquedistas. Para o período 1987-2014, a pesquisa revelou 46 acidentes, incluindo 2 em Portugal envolvendo múltiplos aviões.

The database of several Safety Investigation Authorities, namely Belgian AAIU, was searched for the occurrence of accidents involving parachute dropping flights. For the period 1987-2014, the search revealed 46 accidents, including 2 in Portugal and involving multiple airplanes.

Os dados recolhidos mostraram 5 fases de voo distintas:

- A descolagem,
- A subida inicial, após a descolagem, até uma altitude segura para um salto com um paraquedas.
- O voo de trânsito, uma subida até a altitude de largada.
- A largada, para o qual a aeronave diminui a velocidade, para permitir a saída dos paraquedistas.
- A descida, às vezes com paraquedistas e/ou passageiros a bordo, até à aterragem.

The data gathered showed 5 distinct flight phases:

- The take-off,
- The initial climb, following the take-off, up to a safe altitude for a jump with a parachute.
- The transit flight, a climb up to the dropping altitude.
- The dropping, for which the airplane slows down, to allow the dropping of parachutists.
- The descent, sometimes with parachutists and/or passengers on board, up to the landing.

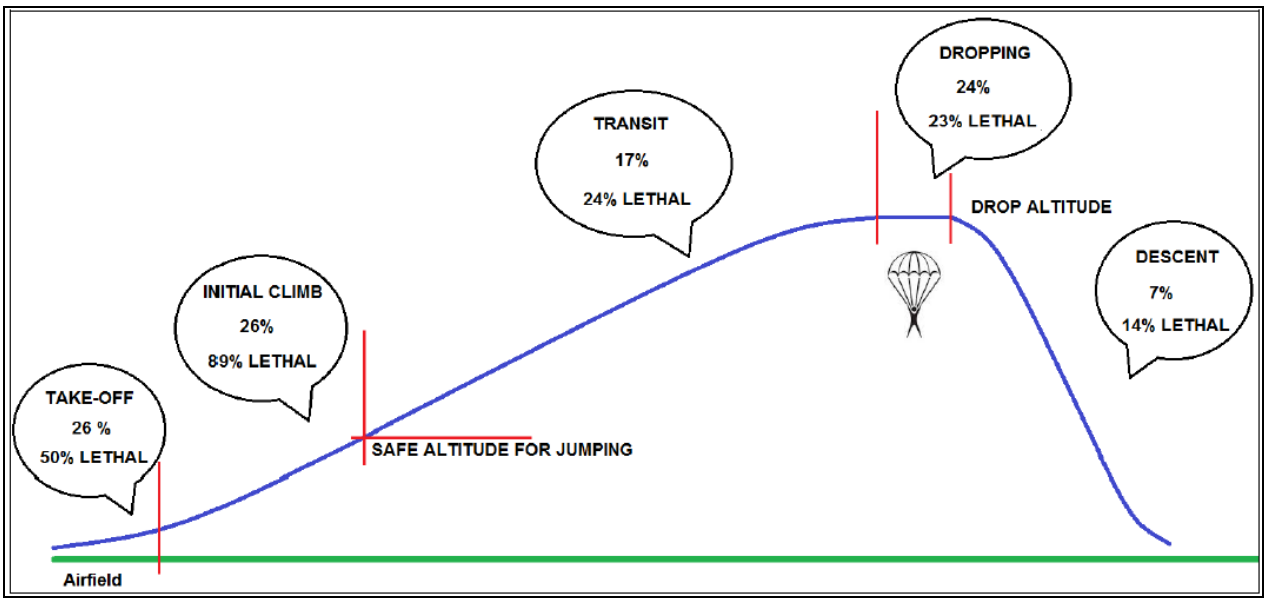


Figura 28 || Figure 28
Proporção de acidentes relacionados com a fase de voo || Proportion of accidents related to flight phase

As fases de voo mais críticas são a descolagem e a subida inicial. As causas identificadas deste tipo de acidente incluíram:

- Falha do motor, em 41% dos casos;
- Preparação de voo inadequada (45%), incluindo:
  - Peso e/ou centragem inadequados (30%),
  - Colocação de compensador incorreto (12%),
  - Preparação inadequada do motor: combustível insuficiente, congelamento do carburador.

Isto é acompanhado de perto pela fase de largada:

- Ao atingir a altitude de largada, a aeronave tem que diminuir a velocidade para uma velocidade próxima à velocidade de perda, para permitir que os paraquedistas saltem. Em 45% dos casos, o avião entrou em perda seguido de *vrille*, dificultando a saída do paraquedista (porém não impossível);
- A segunda causa de acidente nesta fase é o contato involuntário dos paraquedistas (ou seus paraquedas) com a cauda do avião.

Os acidentes durante o voo de trânsito são devidos a:

- Falha do motor (62%), para o qual todos os paraquedistas saltaram em segurança;
- Colisões no ar (38%). Representam todas as fatalidades nesta fase de voo.

Os acidentes durante a descida são principalmente devidos a colisões em voo e um caso específico devido à abertura automática do paraquedas de reserva quando os paraquedistas permaneceram a bordo durante a descida.

The most critical flight phases are the take-off and the initial climb. The identified causes of this type of accident included:

- Engine failure, in 41% of the cases;
- Inadequate flight preparation (45%), including:
  - Inadequate weight and/or balance (30%),
  - Improper trim setting (12%),
  - Inadequate engine preparation: Fuel starvation, carburettor icing.

This is closely followed by the drop phase:

- When reaching the dropping altitude, the airplane has to slow down at a speed close to the stall speed, in order to allow parachutists to jump. In 45% of the cases, the airplane actually stalled and entered into a spin, making an escape of the parachutist difficult (however not impossible).
- The second cause of accident in this phase is the involuntary contact of parachutists (or their parachutes) with the airplane's tail.

The accidents during the transit flight are due to:

- Engine failure (62%), for which all parachutists jumped to safety;
- Mid-air collisions (38%). They account for all the fatalities in this flight phase.

The accidents during descent are mostly due to mid-air collisions and one particular case due to the automatic opening of the reserve parachute when parachutists remained on board during descent.

1.18.2 Acidentes semelhantes com o Pilatus PC-6 || Pilatus PC-6 accidents showing similarities

A investigação considerou interessante identificar alguns outros acidentes com o Pilatus PC-6 que mostram semelhanças com o acidente, ou seja, uma falha estrutural de uma asa e / ou um evento do compensador do estabilizador horizontal.

The investigation deemed it interesting to identify few other Pilatus PC-6 accidents showing similarities with the accident in, i.e. a structural failure of a wing and/or a horizontal stabilizer trim event.

Data Date	Local Place	Tipo Type	Evento Event	Causa Cause
01-11-1997	Laon (FR)	B2-H2	Perda de controlo e separação de ambas as asas Loss of control and both wings separation	Perda de controlo de profundidade causado pela inadequada posição do compensador Loss of pitch control caused by inadequate pitch trim position
13-03-2000	Moorsele (BE)	B2-H4	Perda de controlo imediatamente após a descolagem Loss of control immediately after take-off	Posição incorreta de nariz para cima do atuador do compensador do estabilizador horizontal Incorrect full nose up setting of the horizontal stabilizer trim actuator
09-06-2002	EBNM (BE)	B2-H4	Perda de controlo imediatamente após a descolagem Loss of control immediately after take-off	Posição incorreta de nariz para cima do atuador do compensador do estabilizador horizontal Incorrect full nose up setting of the horizontal stabilizer trim actuator
15-05-2004	Agen (FR)	B2-H2	Falha do fixador do atuador do compensador do estabilizador horizontal Horizontal stabilizer trim actuator attachment failure	Fissura não detetada durante as inspeções periódicas Crack not detected during periodical inspections
30-05-2008	Lillo (ES)	B2-H4	Separação em voo da asa esquerda e do estabilizador horizontal Left wing and horizontal stabilizer separation in flight	Sobrecarga estrutural causada por entrada em zona de forte tempestade Load in excess of design load caused by entering in an area with heavy storm conditions.
19-10-2013	Gelbressee (BE)	B2-H4	Separação em voo da asa esquerda Left wing separation in flight	O montante da asa esquerda cedeu devido a sobrecarga excessiva por aceleração g negativa The left wing strut failed under excessive negative g overload

1.18.3 Testemunhas || Testimony

1.18.3.1 Declarações das testemunhas || Witness Statements

Os 7 passageiros a bordo da aeronave foram entrevistados pela investigação. A localização respetiva de cada testemunha é mostrada na figura n.° 29.

The seven passengers aboard the aircraft were interviewed by the investigation. The respective location of each witness is shown in figure n.° 29.

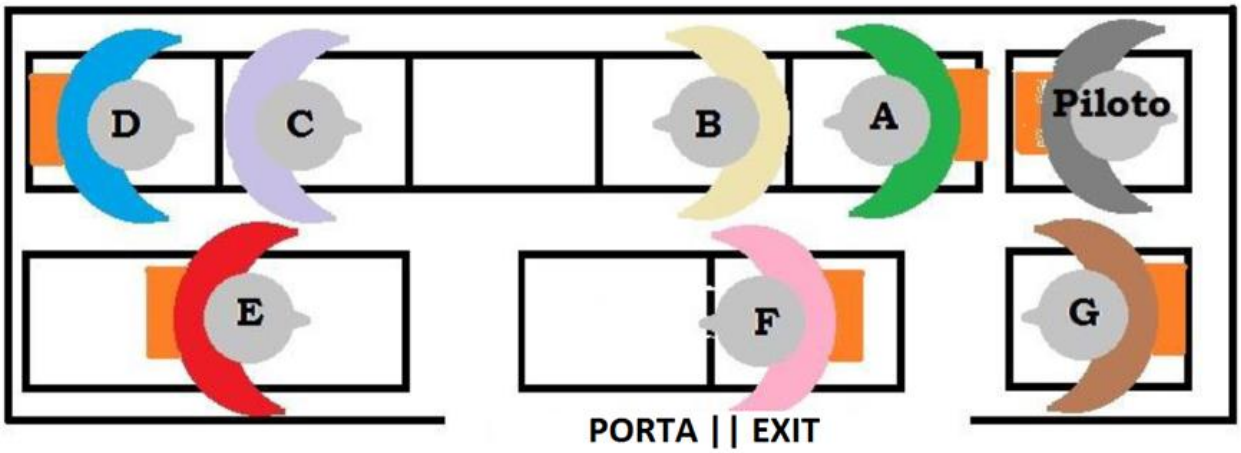


Figura 29 || Figure 29
Localização de cada testemunha na aeronave || Respective location of each witness

1.18.3.2 Testemunhas E e F || Witnesses E and F

As testemunhas E e F estavam sentadas junto da porta da aeronave e foram os primeiros ocupantes a abandoná-la. Disseram que quando a aeronave estava a subir de 7.000 para 8.000 pés, a aeronave balançou, depois estabilizou e que eles abriram a porta. De seguida ouviram um estrondo vindo da parte de trás e a aeronave começou a descer e a rodar para o lado direito entrado em *vrille* (spin). Ambos não sabem se soltaram ou se foram empurrados para fora da aeronave pelas forças geradas no *vrille*. Durante a queda livre viram os outros paraquedistas e a aeronave a desintegrar-se em três secções, cabine, asas e cauda. Abriram o paraquedas manualmente aos 2.320 e 1.650 pés respetivamente.

Witnesses E and F were sitting by the aircraft door and were the first to leave it. They said that when the aircraft was rising from 7.000 to 8.000 feet, the aircraft swung, then stabilized and they opened the door. Then they heard a bang coming from the back and the aircraft began to descend and turn to the right side in spin. Both do not know if they jumped or if they have been pushed out of the aircraft by the forces generated in the spin. During the free fall they saw the other skydivers and the aircraft disintegrating into three sections, cabin, wings and tail. They opened the parachute manually at 2.320 and 1.650 feet respectively.

1.18.3.3 Testemunhas D e C || Witnesses D and C

As testemunhas D e C saltaram em *tandem* e estavam sentadas no banco na parte traseira do lado esquerdo, voltadas para a cabine.

Disseram que por volta dos 8.000 pés ouviram um estrondo vindo da cauda da aeronave e que esta afundou. O piloto estabilizou a aeronave e que de seguida esta entrou em *vrille* para a direita. De repente a aeronave saiu de *vrille* mas partiu na zona central de ligação das asas com a fuselagem e os paraquedistas foram sugados para a atmosfera caindo em queda livre. Abriram manualmente o paraquedas aos 3.800 pés.

The witnesses D and C jumped in tandem and were seated at the rear of the left-side bench, facing to the cabin.

They said around 8.000 feet they heard a bang coming from the tail of the aircraft and that it sank. The pilot stabilized the aircraft and then it went into spin to the right. Suddenly the aircraft came out of spin but ripped open in the central area of connecting wings with the fuselage and the skydivers were sucked into the atmosphere falling into free-fall. They manually opened the parachute at 3.800 feet.

1.18.3.4 Testemunhas A e B || Witnesses A and B

As testemunhas A e B formavam outra equipa em tandem. Elas estavam sentadas no banco do lado esquerdo viradas para trás. Ambas ficaram inconscientes durante a desintegração da aeronave, caíram em queda livre e o paraquedas de emergência com ativação barométrica abriu automaticamente aos 2.017 pés.

The witnesses A and B formed another tandem team. They were seated on the left-side bench facing backwards. Both were unconscious during the disintegration of the airplane, fell in free-fall and the emergency parachute with barometric activation opened automatically at 2.017 feet.

1.18.3.5 Testemunha G || Witness G

A testemunha G, que estava sentada ao lado do piloto voltada para trás, disse que andou aos tombos dentro da aeronave e que ficou inconsciente. Durante a desintegração da aeronave foi sugado para a atmosfera e o paraquedas de emergência com ativação barométrica abriu automaticamente aos 797 pés.

The witness G, who was sitting next to the pilot backwards, said he tumbled into the aircraft and became unconscious. During the disintegration of the aircraft he was sucked into the atmosphere and the emergency parachute with barometric activation opened automatically at 797 feet.

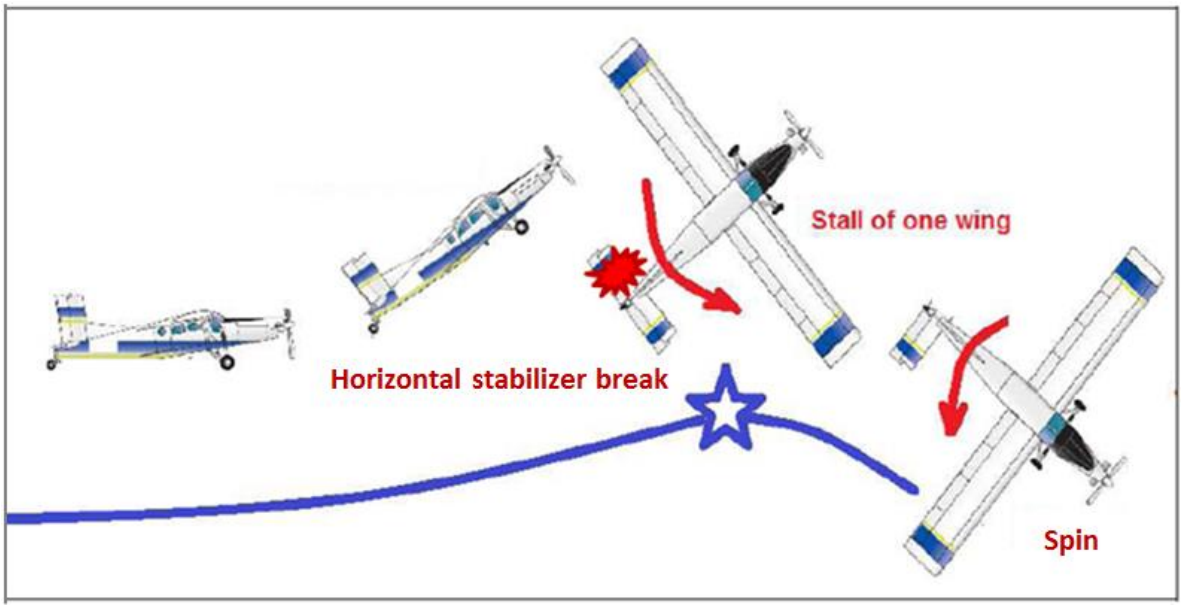


Figura 30 || Figure 30
Reconstrução do evento de acordo com os testemunhos dos paraquedistas e da análise dos destroços pela investigação || Reconstruction of the event according to the skydivers' testimony and the analysis of the wreckage by the investigation.

1.18.4 *Vrille* || Spin

Trata-se de uma manobra possível por qualquer aeronave que permita a entrada em perda. Neste caso a aeronave entrou em *Vrille* devido a uma falha estrutural, perda do estabilizador horizontal do lado esquerdo. A vrille não foi intencional.

A recuperação da manobra, na sua forma mais clássica (Spin normal), é constituída por dois passos fundamentais: *rudder* oposto (ao do sentido da rotação) para contrapor ao *yaw* existente, e após uma ligeira pausa, *elevator* firmemente para a frente (apenas o necessário) para parar a rotação.

This is a possible maneuver for any aircraft in which a stall may occur. In this case, the aircraft entered in spin due to a structural failure, the horizontal stabilizer loss on the left side. No intentional spin was attempted.

The recovery of the manoeuvre, in its most classical form (normal spin), it consists of two fundamental steps: the opposite rudder (to the direction of rotation) to counteract the existing yaw, and after a slight pause, elevator firmly forward (only necessary) to stop the rotation.

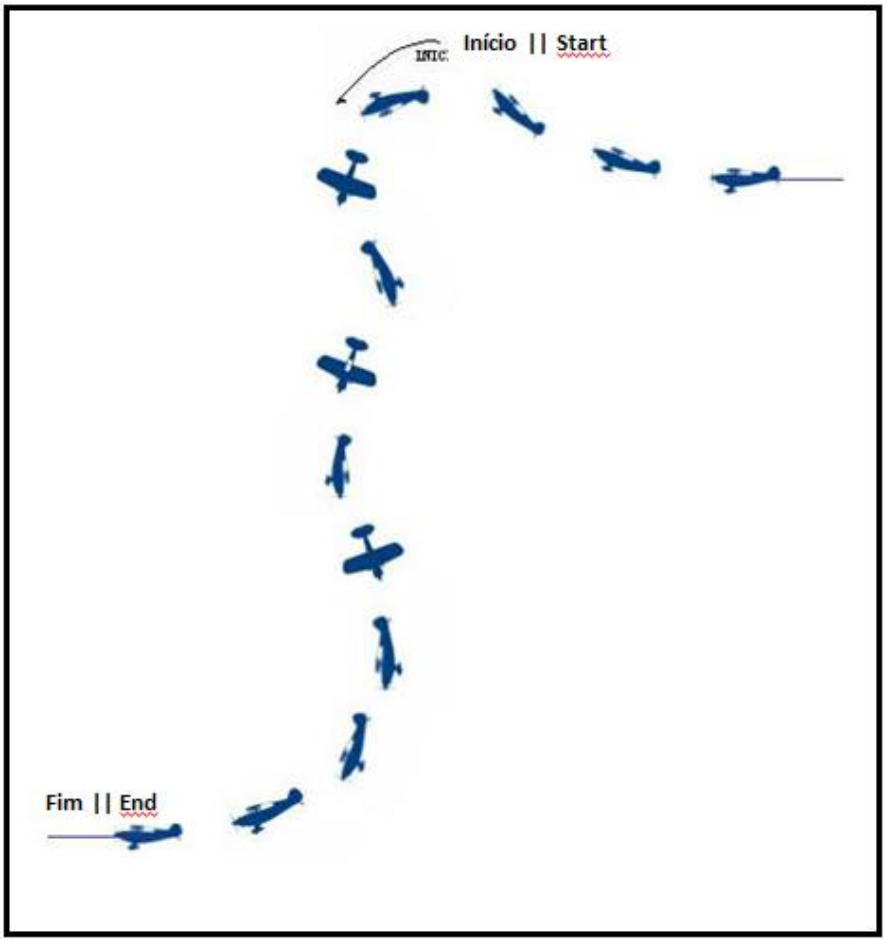


Figura 31 || Figure 31
Manobra de *vrille* || Spin manoeuvre

1.18.5 O processo de investigação || The safety investigation process

A investigação centrou-se sobre os seguintes aspectos:

- Inspeção visual do local do acidente, reconstituição da aeronave com as partes e peças encontradas;
- Exame detalhado dos comandos de voo (cabos, superfícies);
- Desmontagem e exame pormenorizado do atuador do compensador;
- Exame detalhado do motor e da hélice;
- Inspeção laboratorial dos:
  - *A/C sided HT-trim actuator fitting*
  - *LH and RH elevator Flettner-tab push-pull rod*
  - *RH wing Flettner-tab push-pull rod*
  - *LH wing strut attachment (wing side)*
- Determinação da sequência de ruptura da estrutura do avião;
- Exame da documentação técnica e de manutenção do avião;
- Exame dos dados barométricos dos dispositivos automáticos de abertura dos paraquedas;
- Entrevista com os paraquedistas que estavam a bordo da aeronave.

The Safety Investigation focused on the following aspects:

- Detailed examination of the wreckage, reconstitution of the airplane with all found detached parts;
- Detailed examination of the flight controls (cables, surfaces);
- Disassembly and detailed examination of the trim actuator;
- Detailed examination of the engine and propeller;
- Laboratory inspection of the:
  - A/C sided HT-trim actuator fitting,
  - LH and RH elevator Flettner-tab push-pull rod,
  - RH wing Flettner-tab push-pull rod,
  - LH wing strut attachment (wing side);
- Determination of the rupture sequence of the airplane structure;
- Examination of the airplane technical and maintenance documentation;
- Examination of the barometric data of the automatic parachute opening devices;
- Interview of the parachutists who were on board the aircraft.

1.19 Técnicas de investigação úteis ou eficazes || Useful or effective investigation techniques

Para a investigação, foi útil e eficaz o recurso a microscópio eletrónico de varrimento, com alta ampliação, para a determinação do modo de falha por observação das superfícies fraturadas.

The Investigation found useful and effective the failure mode analysis by the observation of fractured surfaces with a scanning electron microscope, at high magnification.

2. ANÁLISE || ANALYSIS

2.1. Causa provável || Probable cause

Conforme observado na secção 1.12.1.3. 'Fixação do atuador do compensador ao avião', no exame aos destroços a fixação do atuador do compensador foi encontrada partida e foi enviada para uma investigação mais aprofundada, tendo os fragmentos do lado do atuador sido enviados à Empa para observações com um microscópio eletrónico de varredura, com alta ampliação (apêndice 1).

As noted in section 1.12.1.3. 'A/C sided HT-trim actuator fitting', in the wreck examination the fixation of the compensator actuator was found broken and was sent for further investigation. The fragments on the actuator side were sent to Empa for observations with a scanning electron microscope, with high magnification (appendix 1).

As observações do acessório de fixação *HT-trim* com um microscópio eletrónico de varredura, com alta ampliação, mostraram que ambas as superfícies fraturadas (RH e LH) apresentavam fissuras significativas por fadiga. As fendas de fadiga começaram em vários pontos, o que significa que não há uma única origem da fenda. Enquanto a fenda de fadiga na fratura de RH quase separou a secção transversal completa, a fratura de LH mostra uma parcela significativa da fratura de sobrecarga dúctil (rutura final).

Observations of the HT-trim fitting with a scanning electron microscope, with high magnification, showed that both fractured surfaces (RH and LH) had significant cracks due to fatigue. Fatigue cracks have started in several places, which means that there is not a single source of the crack. While the fatigue crack at the HR fracture almost separated the entire cross-section, the LH fracture shows a significant portion of ductile overload fracture (final rupture).

A investigação entende que, depois da fratura do acessório de fixação *HT-trim*, o estabilizador horizontal ficou solto, sem controlo e entrou em vibração, provocando a fratura do lado esquerdo.

The investigation considers that, after the fracture of the HT-trim attachment accessory, the horizontal stabilizer was loose, uncontrolled and vibrated, causing the fracture of the left side.

A aeronave deixou de ter condição aeronavegável e o piloto perdeu o controlo da mesma, tendo entrado numa condição de *vrille*.

The airplane ceased to have an airworthy condition and the pilot lost control of the aircraft and entered in spin condition.

Depois de ter entrado em *vrille* a aeronave foi sujeita a forças e cargas para a qual não foi concebida, provocando o rompimento da fuselagem na zona central e consequente desintegração da aeronave em voo.

After entering in spin the airplane was subjected to forces and loads for which it was not designed, causing the rupture of the fuselage in the central zone and consequent disintegration of the aircraft in flight.

3. CONCLUSÃO || CONCLUSION

3.1. Evidências || Findings

- O piloto estava devidamente licenciado e tinha experiência suficiente para efetuar o voo.
- A aeronave possuía um certificado de aeronavegabilidade válido e foi mantida de acordo com um programa de manutenção aprovado.
- A massa e o centro de gravidade da aeronave estavam dentro dos limites recomendados.
- O avião decolou da pista 35 no aeródromo Figueira de Cavaleiros. A bordo estavam o piloto e sete paraquedistas.
- Dois paraquedistas estavam fazendo os primeiros saltos, em *tandem* ligados por um arnês ao instrutor.
- No momento do acidente, a atmosfera estava estável.
- Quando a aeronave estava a oeste do aeródromo a uma altitude aproximada de 7.000 pés, o avião desintegrou-se.
- Antes da desintegração da aeronave, a porta direita foi aberta e dois paraquedistas saltaram. Uma vez no ar, eles conseguiram abrir seus paraquedas a uma altitude suficiente para chegar ao chão normalmente.
- Os outros cinco paraquedistas foram sugados para a atmosfera na desintegração da aeronave. Um paraquedas em *tandem* com dois paraquedistas conseguiu abrir o seu paraquedas manualmente e os outros ficaram inconscientes e os paraquedas abriram automaticamente.
- O piloto livrou o cockpit, mas provavelmente ficou inconsciente e não abriu o paraquedas.
- Como resultado da desintegração da aeronave, as restantes partes continuaram no seu movimento descendente até ao impacto com o solo.

- The pilot was properly licensed and sufficiently experienced for the flight.
- The aircraft had a valid Certificate of Airworthiness and had been maintained in accordance with an approved maintenance schedule.
- The aircraft's weight and centre of gravity were within the prescribed limits.
- The airplane took off from runway 35 at the Figueira de Cavaleiros Aerodrome. Onboard were the pilot and seven skydivers.
- Two skydivers were making their first jumps, in tandem attached by a harness to an instructor.
- At the time of the accident, the atmosphere was stable.
- When the aircraft was west of the aerodrome at an approximate altitude of 7.000 ft, the airplane disintegrated.
- Before the airplane disintegration the right door was opened and two skydivers jumped. Once in the air, they managed to open their parachutes at a sufficient altitude that they were able to reach the ground normally.
- The other five skydivers were sucked into the atmosphere in the disintegration of the airplane. One tandem parachute with two skydivers managed to open their parachute manual and the others were unconscious and the parachutes opened automatic.
- The pilot left the cockpit but probably became unconscious and did not open the parachute.
- As a result of the disintegration, the remaining aircraft parts continued downfalling until the impact with the ground.

- Fragmentos das peças da aeronave foram encontrados num comprimento de aproximadamente 1.500 metros e uma largura de cerca de 500 metros e foram amplamente dispersos, com um alinhamento com a direção do voo, de oeste para leste.
- A análise do acessório de fixação do estabilizador horizontal revelou que as fraturas encontradas nela ocorreram como resultado de fissuras por fadiga.
- O CAMO afirma que a última inspeção Dye-penetrante foi feita em 2015 como parte de uma revisão parcial. Contudo, apenas foi possível evidenciar inspeção efetiva à área em 2012. Não foi apresentado relatório de NDTs.

- Fragments of the aircraft parts were found over a length of approximately 1500 meters and a width of about 500 meters and were widely dispersed, with an alignment with the direction of the flight, from west to east.
- The analysis of the horizontal stabilizer trim attachment fitting revealed that the fractures found on it occurred as a result of fatigue cracking.
- The CAMO states that the last dye-penetrant inspection was done in 2015 as part of a partial overhaul. However, it was only possible to demonstrate an effective inspection to the area on 2012. No NDT report was shown.

3.2. Causa provável || Probable Cause

A investigação considera que, depois da fratura do acessório de fixação *HT-trim*, o estabilizador horizontal ficou solto, sem controlo e entrou em vibração, provocando a fratura do lado esquerdo do estabilizador horizontal.

The investigation considers that, after the fracture of the HT-trim attachment accessory, the horizontal stabilizer was loose, uncontrolled and vibrated, causing the fracture of the left side of the horizontal stabilizer.

3.3. Fatores de segurança contribuintes || Contributing safety factors

- Falha no método de inspeção pela organização part 145 das peças críticas identificadas no SB 53-001 R1.
- A falta de monitorização do operador da aeronave pelo regulador (ANAC).

- Failure on the inspection method by part145 organization to the critical parts identified on SB 53-001 R1.
- The weakness of regulator (ANAC) oversight to the aircraft operator.

4. RECOMENDAÇÕES DE SEGURANÇA| |SAFETY RECOMENDATIONS

De acordo com o artigo 17.3 do Regulamento Europeu (UE) 996/2010 do Parlamento Europeu e Conselho, de 20 de outubro de 2010, sobre investigação e prevenção de acidentes e incidentes na aviação civil, a formulação de uma recomendação de segurança não constitui, em caso algum, presunção de culpa ou de responsabilidade relativamente a um acidente, a um incidente grave ou a um incidente. O destinatário de uma recomendação de segurança deve informar a autoridade responsável pelas investigações de segurança que formulou a recomendação das ações tomadas ou em consideração, nas condições descritas no artigo 18 do referido Regulamento.

In accordance with Article 17.3 of European Regulation (EU) 996/2010 of the European Parliament and Council of 20 October 2010 on the investigation and prevention of accidents and incidents in civil aviation, a safety recommendation shall in no case create a presumption of blame or liability for an accident, a serious incident or an incident. The addressee of a safety recommendation shall inform the safety investigation authority which issued the recommendation of the actions taken or under consideration, under the conditions described in Article 18 of the aforementioned Regulation.

As seguintes recomendações são emitidas para mitigar as questões de segurança operacional identificadas nesta investigação.

The following recommendations are issued to address the safety issues identified in this investigation.

4.1. Fixadores do compensador do estabilizador horizontal (superior e inferior) || Horizontal stabilizer trim attachment fitting (upper and lower)

De acordo com o manual de manutenção do Pilatus PC-6 a fixação do atuador do compensador deve ser inspecionado e examinado de acordo com AMM, 53-30-00 a cada 3.500 horas de voo ou 7 anos, o que ocorrer primeiro.

According to the Pilatus PC-6 maintenance manual the trim actuator attachment must be inspected and examined according to AMM, 53-30-00 every 3.500 flight hours or 7 years, whichever occurs first.

Chapter 53 - Fuselage Stabilizer Trim Attachment Components, FR12A	Examine (Ref. 53-30-00. Page Block 601)	3500 flying hours or 7 years (whichever comes first)

A investigação apurou que os fixadores do compensador do estabilizador horizontal (ambas as configurações, figura n.º 7) estão sujeitos a cargas e forças substanciais durante todo o voo.

The investigation has found that horizontal stabilizer trim attachment fittings (upper and lower, figure 7) are subject to substantial loads and forces throughout the flight.

A investigação recomenda que os fixadores do compensador do estabilizador horizontal sejam substituídos em vez de serem examinados, a cada 3.500 horas de voo ou 7 anos, o que ocorrer primeiro, até serem redesenhados pelo fabricante.

The investigation recommends that horizontal stabilizer trim attachment fittings to be replaced instead of being examined, every 3.500 flight hours or 7 years, whichever comes first, until further part redesign by OEM.

À EASA	**To EASA**
Recomendação de Segurança N.º 05/2018	**Safety Recommendation N.º 05/2018**
Recomenda-se que a Agência Europeia para a Segurança da Aviação, EASA, emita/reveja com carácter de urgência a Diretiva de Aeronavegabilidade (AD 2016-0202-E) aos aviões tipo Pilatus PC-6, introduzindo um tempo de vida útil ou um limite para a primeira inspeção tecnicamente eficaz, seguido de inspeções repetitivas para o acessório de fixação inferior do compensador do estabilizador horizontal.	**It is recommended that the European Aviation Safety Agency, EASA, urgently issue/revise the Airworthiness Directive (AD 2016-0202-E) to Pilatus PC-6 airplanes type to introduce a life limit or a threshold for a technical effective inspection followed by repetitive inspections to the horizontal stabilizer lower trim attachment fitting.**

4.2. Questão de segurança || Safety issue

A fraqueza do quadro jurídico e da supervisão efetiva

No decurso da investigação, o GPIAAF concluiu haver a necessidade de uma melhoria do quadro organizacional das operações de voo envolvidas em atividades de paraquedismo, bem como uma melhoria do monitoramento e vigilância dessas atividades, tanto internamente quanto pela autoridade competente de supervisão. Portanto, o GPIAAF, considerando o volume da atividade e o potencial perigo para os ocupantes das aeronaves envolvidas, fez a seguinte recomendação para a ANAC em maio de 2017:

The weakness of the legal framework and effective oversight

During the investigation, GPIAAF concluded that an improvement of the organizational framework of the flight operations involved in parachuting activities, as well as an improvement of the monitoring and surveillance of these activities, are needed, both internally and by the competent oversight authority. Therefore, GPIAAF, considering the volume of the activity and the potential danger to the occupants of the airplanes involved, made the following recommendation to ANAC (CAA) on May 2017:

À ANAC **Recomendação de Segurança N.º 01/2017**	**To ANAC** **Safety Recommendation N.º 01/2017**
Considerando o volume de atividade e do perigo potencial para os ocupantes das aeronaves envolvidas, o GPIAAF recomenda à ANAC para rever os requisitos regulamentares pertinentes à atividade de paraquedismo, a fim de aumentar a segurança desta atividade a um nível aceitável, bem como adaptar o nível de supervisão.	**Considering the volume of the activity and the potential danger to the occupants of the aircrafts involved, GPIAAF recommends ANAC to review the regulatory requirements pertaining to the activity of parachute droppings in order to increase the safety of this activity to an acceptable level, as well as adapting the level of oversight.**

A ANAC em resposta a esta Recomendação de Segurança (N.º 01/2017), informou através do ofício 33/DSO/PSA/2018 em 27 de abril de 2018, o seguinte:

"À data do acidente - 19 de junho de 2016 - a atividade de lançamento de paraquedistas encontrava-se regulamentada pelo Decreto-Lei n.º 44/2013, de 2 de abril, que estabelece o regime jurídico aplicável à atividade de trabalho aéreo, conformando-o com a disciplina do Decreto-Lei n.º 92/2010, de 26 de julho, que transpôs a Diretiva n.º 2006/123/CE, do Parlamento Europeu e do Conselho, de 12 de dezembro de 2006, relativa aos serviços no mercado interno.

A aeronave acidentada, D-FSCB, era, a data do acidente, operada pelo operador [3] a quem esta Autoridade havia concedido, em 21 de dezembro de 2015, ao abrigo do artigo 26.° do identificado diploma legal, uma autorização para a livre prestação de serviços de trabalho aéreo em espaço aéreo sob jurisdição nacional (Autorização n.º OS/2015-VCA).

De acordo com esta autorização, o operador [3] ficava autorizado a operar a aeronave Pilatus PC-6/B2-H4, com as marcas de nacionalidade e de matricula D-FSCB, para realizar trabalho aéreo na modalidade de lançamento de paraquedistas.

Não constava, assim, esta aeronave do Certificado de Operador de Trabalho Aéreo (COTA) do operador Aerovip.

A partir de 21 de abril de 2017, a atividade de trabalho aéreo, nomeadamente o lançamento de paraquedistas, passou a ser regulada pelo Regulamento (UE) n.º 965/2012, da Comissão, de 5 de outubro de 2012, que estabelece os requisitos técnicos e os procedimentos administrativos para as operações aéreas, em conformidade com a Regulamento (CE) n.º 216/2008 do Parlamento Europeu e do Conselho, na redação que lhe foi introduzida pelo Regulamento (UE) n.º 379/2014, da Comissão, de 7 de abril de 2014.

De facto, o último dos identificados Regulamentos (UE) aditou ao Regulamento (UE) N.º 965/2012 o Anexo VIII relativo as Operações Especializadas (Parte 5PO), nas quais se incluem, como se referiu o lançamento de paraquedistas, na medida em que esta Autoridade não classificou esta atividade como sendo de alto risco.

The ANAC in response to this Safety Recommendation (No. 01/2017), reported through the craft 33/DSO/PSA/2018 on 27 April 2018, the following:

"At the time of the accident, 19 June 2016, the skydiving activity was regulated by Decree-Law n.º 44/2013 of April 2nd, establishing the legal regime applicable to air work activity compliant with the discipline of Decree-Law n º 92/2010 of 26 July, which transposed Directive No.2006/123/EC of the European Parliament and of the Council of 12 December 2006, on services in the internal market.

The accident aircraft, D-FSCB, was at the date of the accident, operated by the operator [3], who, on 21 December 2015, granted this authorization under Article 26 to provide air work services in airspace under national jurisdiction (Authorization n.º OS / 2015-VCA).

According to this authorization, the operator [3] was authorized to operate the Pilatus PC-6 / B2-H4 aircraft, with the registration marks D-FSCB, to perform aerial work in the skydiving activity.

This aircraft was not included in the Air Operator Certificate (COTA) of the operator Aerovip.

After 21 April 2017, aerial work, in particular the skydiving, became regulated by (EU) No 965/2012 of the Commission of 5 October 2012, laying down the technical requirements and administrative procedures for air operations in accordance with Regulation (EC) No 216/2008 of the European Parliament and of the Council, as amended by Commission Regulation (EU) No 379/2014 of 7 April 2014.

In fact, the last of the identified Regulations (EU) added Annex VIII on Specialized Operations (Part SPO) to Regulation (EU) No. 965/2012, which includes skydiving this Authority did not classify this activity as being a high risk.

[3] Operador particular. Nos termos legais, a identidade do mesmo não é revelada neste relatório. || Particular operator. According to legislation, it will not be named in this report.

Resulta, assim, de tanto quanta se deixou dito, que, ao contrário, do referido na Recomendação de Segurança, não há necessidade de rever os requisitos regulamentares desta atividade, na medida em que todos os aspetos da mesma se encontram regulamentados. E, igualmente, esta atividade, a par das restantes relativas as Operações Especializadas (Parte SPO), objeto de supervisão par parte da ANAC.

É entendimento desta Autoridade que o acidente tem na base problemas de *type design* da aeronave e não na necessidade de rever os requisitos regulamentares existentes ou de incrementar a supervisão da atividade de lançamento de paraquedistas."

Com esta resposta da ANAC, o GPIAAF considera que a recomendação de segurança n.º 01/2017 está encerrada, o que será devidamente registado no repositório central Europeu de recomendações de segurança na aviação (SRIS).

It follows therefore, from what has been said, and opposing to what is stated in the Safety Recommendation, there is no need to review the regulatory requirements of this activity, since all aspects of it are regulated. In addition, this activity is object of supervision by ANAC, along with all others related to Specialized Operations (SPO Part).

In the understanding of this Authority, the accident has in his bases, problems with aircraft design rather than on the need to review existing regulatory requirements or to increase oversight of the skydiving activity."

With this reply from ANAC, GPIAAF considers that safety recommendation No. 01/2017 is closed, which will be duly registered in the European central repository for safety recommendations in aviation (SRIS).

5. ALTERAÇÕES REALIZADAS APÓS O ACIDENTE || CHANGES MADE FOLLOWING THE ACCIDENT

5.1 PILATUS AIRCRAFT Ltd

A Pilatus emitiu o BOLETIM DE SERVIÇO N.º: 53-003 R1 que consta no apêndice n.º 3 deste relatório.

Pilatus issued SERVICE BULLETIN NO: 53-003R1 which will be described enclosed in the appendix N. 3 to this report.

Naquele documento a Pilatus declara que foram reportados desgaste e fissuras na fixação do compensador do estabilizador e nos componentes estruturais relevantes, nos aviões que realizaram o boletim de serviço emitido pela *Pilatus* (SB) 53-001 Revisão 1, como previamente exigido pela FOCA AD HB-2005-263.

Wear and cracks on the stabilizer-trim attachment and relevant structural components have been reported on aeroplanes having accomplished Pilatus Service Bulletin (SB) 53-001 Revision 1, as previously required by FOCA AD HB-2005-263.

Uma investigação subsequente identificou que a instalação ligeiramente assimétrica e/ou condições de operação podem resultar em vibração forte do estabilizador, causando o início de fissuras no acessório de fixação do compensador do estabilizador ou peça de ligação.

Subsequent investigation identified that slightly asymmetric installation and/or operational conditions may result in strong stabilizer vibration, causing crack initiation in the stabilizer-trim attachment fitting or connecting piece.

Esta condição, se não for detectada e corrigida, pode levar a uma falha da peça de ligação ou conexão, possivelmente resultando na desunião da fixação traseira do estabilizador horizontal, com consequente perda de controlo do avião.

This condition, if not detected and corrected, may lead to a failure of the fitting or connecting piece, possibly resulting in disconnection of the horizontal stabilizer rear attachment, with consequent loss of control of the aeroplane.

Como medida corretiva, o Boletim define um conjunto de operações de inspeção a realizar a fim de detetar eventuais fissuras, com vista à substituição da peça se for o caso. Em alternativa, preconiza a substituição imediata da peça.

As a corrective action, the Bulletin defines a set of inpection operations to be performed in order to detect possible cracks, leading to the part replacement if required. Alternatively to the inspections, the part should be immediately replaced.

Apesar das alterações introduzidas após o acidente, o GPIAAF entende que as mesmas não são inteiramente eficazes para prevenir a recorrência pelo que emite a Recomendação de Segurança n.º 02/2018 constante do presente relatório.

Despite the changes made after the accident, GPIAAF considers that they are not totally effective to prevent recurrence, therefore it issues in this report Safety Recommendation 02/2018.

6. APENDICES || APPENDIXES

- Appendix 1: Empa - Test Report No 5'214'013'174
- Appendix 2: Empa - Test Report No 5'214'013'174-3
- Appendix 3: Pilatus SERVICE BULLETIN NO: 53-003 R1
- Appendix 4: Empa - Test Report No 5'214'013'174-2

Apêndice 1 || Appendix 1: Empa- Test Report No 5'214'013'174

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Empa
Materials Science and Technology

Swiss Transportation Safety
Investigation Board - STSB
Mr. Martin Pohl
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Test Report No 5'214'013'174

Test assignment:	**Laboratory investigation on selected parts removed D-FSCB**
Test object:	Parts removed from Wreckage
Client's ref:	Accident D-FSCB (GPIAA Process 07/ACCID/2016)
Order dated of:	June 27th, 2016
Test object received:	July 5th, 2016
Test performed:	July 2016
Number of pages:	14
Attachments:	Attachment A: Image Gallery

Swiss Federal Laboratories for Materials Science and Technology, Laboratory for Joining Technologies and Corrosion
Dübendorf, 8. August 2016

Principal Investigator:	Technical Supervisor:	Head of Laboratory:
Martin Sauder	Dr. Markus Faller	Dr. Lars Jeurgens

Note: The test results are valid solely for the tested object. The use of the test report for advertizing purposes, any reference to it or the publication of excerpts require the approval of the Empa (see Information Sheet). Test reports and supporting documents are retained for 10 years.

Content

1 Introduction

On the 19th of June 2016, a Pilatus PC-6 Aircraft crashed near Figueira de Cavaleiros, Portugal. The local Authority (GPIAA) responsible for the accident investigation immediately involved the OEM of the aircraft to support the investigation. After some observations at the site of the incident, the STSB also became involved.

The initial investigations indicated a potential need for a fractographic investigation of certain parts. The STSB involved Empa to fulfill this task. An inspection of the wreckage took place on July 5th, 2016 in Viseau, Portugal (STSB, Pilatus, GPIAA, Empa). During the inspection certain fragments from the wreckage were taken to EMPA for investigation, which will be described in this report.

The purpose of this report is to support the investigating authorities and the OEM and not to explain the cause of the accident. The background as to why the following parts have been selected for investigation is not relevant to this report.

2 Investigation

The following parts were taken from the wreckage and transferred to Empa:

- A/C sided HT-trim actuator fitting
- LH and RH elevator Flettner-tab push-pull rod
- RH wing Flettner-tab push-pull rod
- LH wing strut attachment (wing side)

2.1 A/C sided HT-trim actuator fitting

The HT-trim attachment fitting was found broken at the connection to the trim actuator (Figure 1 and Figure 2). Visually, the fractured surfaces appeared partially black (greasy). For a closer investigation, the actuator-sided fragments were slightly cleaned (Ethanol and ultrasonic bath – see Figure 3 and Figure 4).

Observations with a scanning electron microscope, at high magnification, showed that both fractured surfaces (RH and LH) had significant fatigue cracking (Figure 5 to Figure 12). The fatigue cracks started at multiple places, meaning there is not one single crack origin. While the fatigue crack on the RH fracture almost separated the complete cross-section, the LH fracture shows a significant portion of ductile overload fracture (final rupture - Figure 13).

2.2 Flettner-tab push-pull rod

The LH push-pull rod of the elevator Flettner tab was found without the connecting link to the tab (Figure 14 and Figure 15). The corresponding Flettner tab itself was not found.

Compared to the RH rod (Figure 16), it can be seen that the last turn of the thread at the LH rod is mechanically damaged (Figure 17).

2.3 LH-wing strut attachment

The fractured surface of the wing-sided attachment bracket of the LH wing strut (Figure 18) was found with a locally discolored fracture surface (Figure 19). The observed discoloration is a result of a secondary contamination of the fracture surface (brown dirt). The fracture surface itself (Figure 20 and Figure 21) indicates a forced rupture (ductile overload fracture).

3 Discussion and Conclusion

The results documented in this report are solely meant to support the accident investigation, and are not intended to explain the nature of the accident. Therefore, we avoid drawing any conclusions towards the accident's cause or the relevance of the findings in this report.

4 Attachment A: Image Gallery

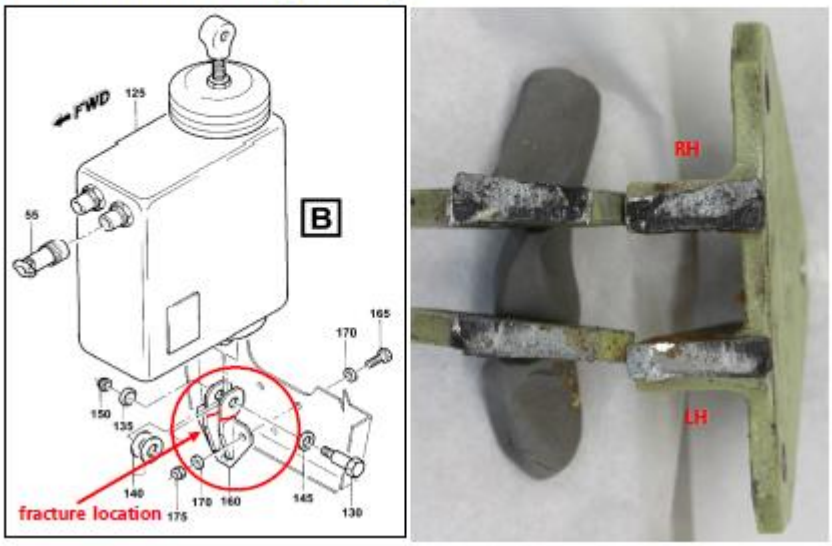

Figure 1: IPC Illustration of the HT-Trim Actuator (IPC) and the failed Fitting (P/N 116.4006.033 A) in as removed condition.

Figure 2: Overview of the failed fitting with P/N

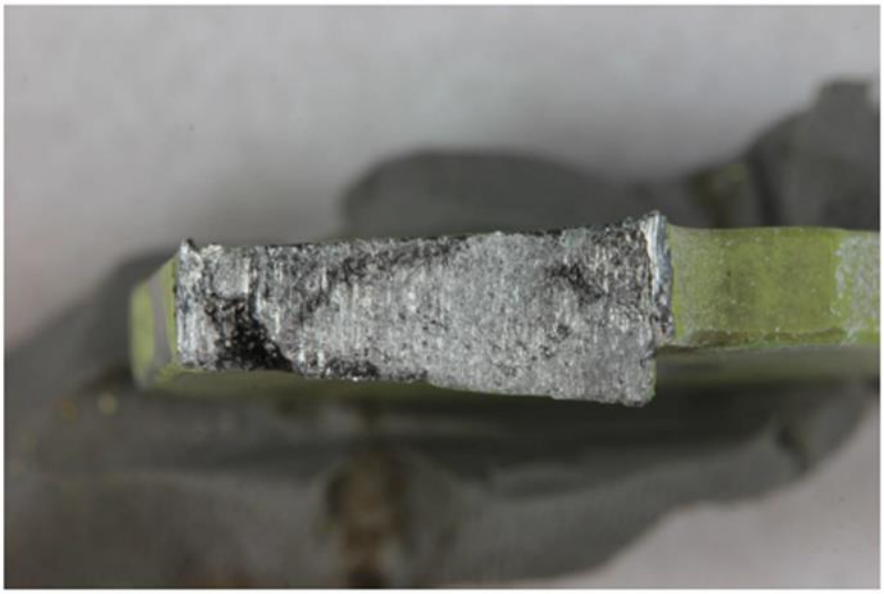

Figure 3: Overview of the RH fracture (actuator side fragment)

Figure 4: Overview of the LH fracture (actuator side fragment)

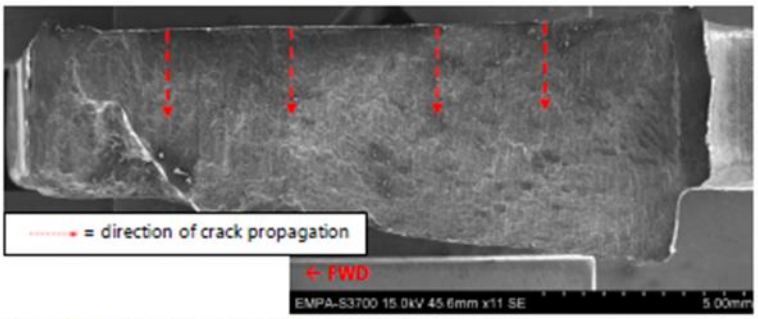

Figure 5: Overview of the RH side fracture surface (actuator side fragment, SEM-Image)

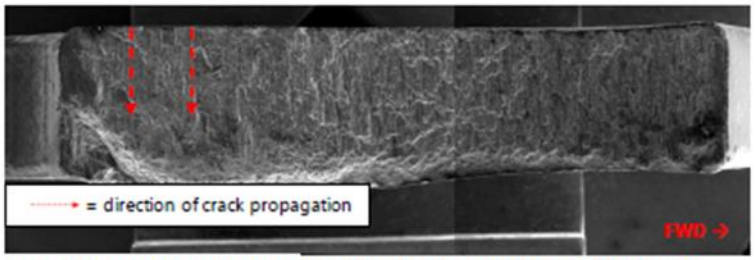

Figure 6: Overview of the LH side fracture surface (actuator side fragment, SEM-Image)

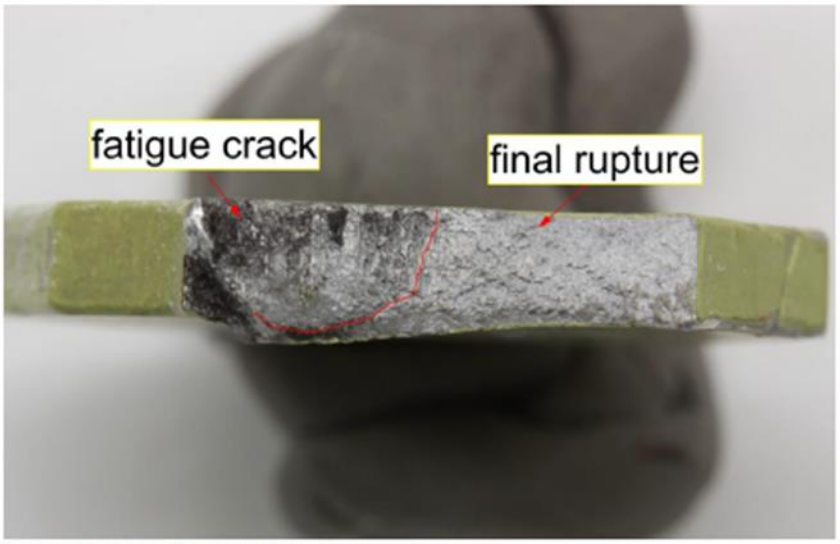

Figure 7: Transition from fatigue to overload at the LH fracture

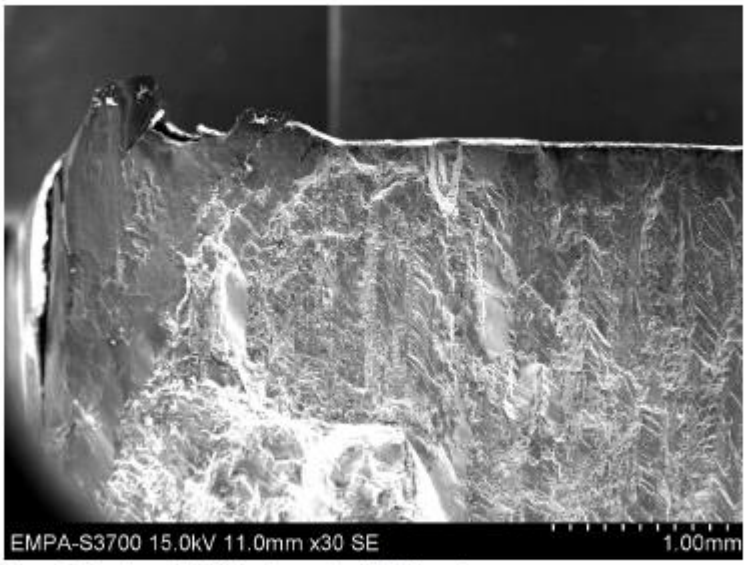

Figure 8: Overview of the RH fracture surface (SEM-Image)

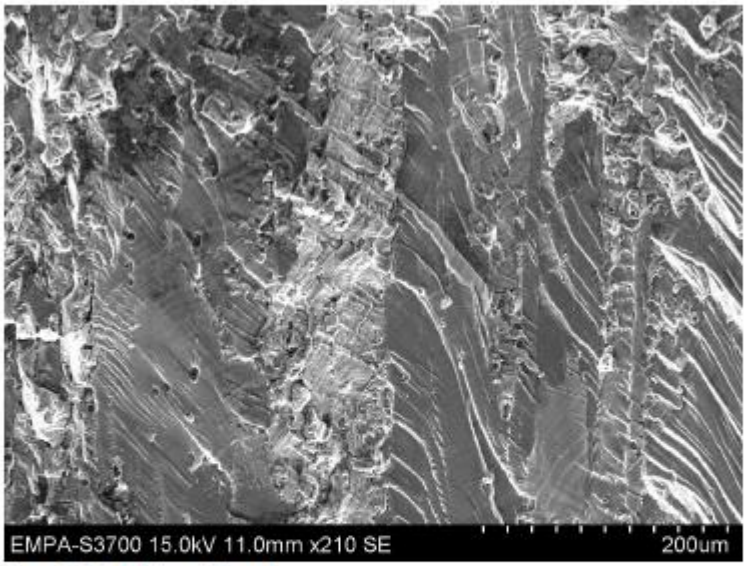

Figure 9: Detailed view of Figure 8

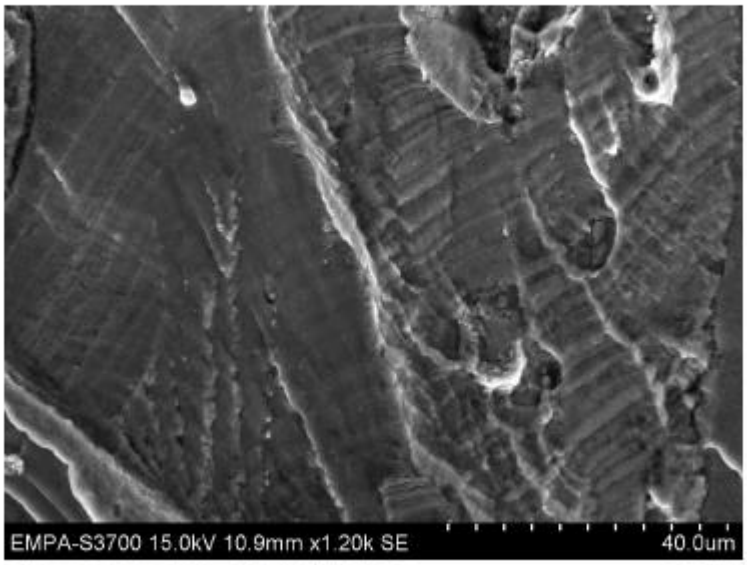

Figure 10: Detailed view of Figure 9

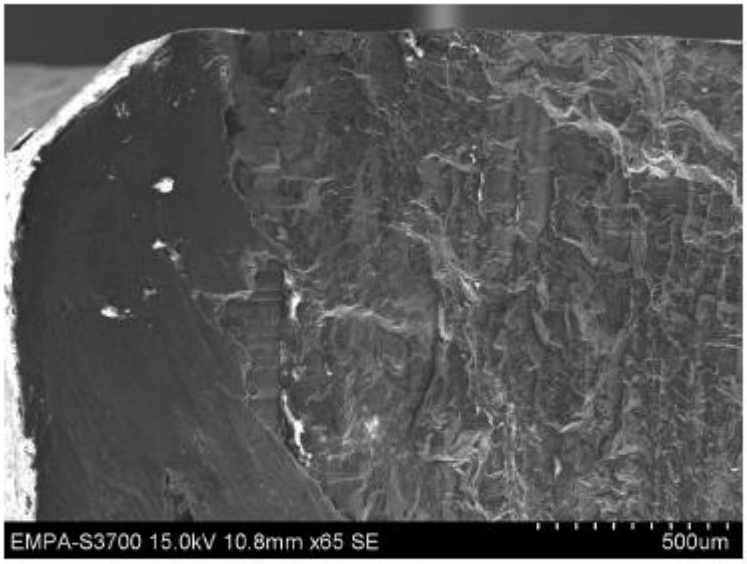

Figure 11: Overview of the LH fracture surface (SEM-Image)

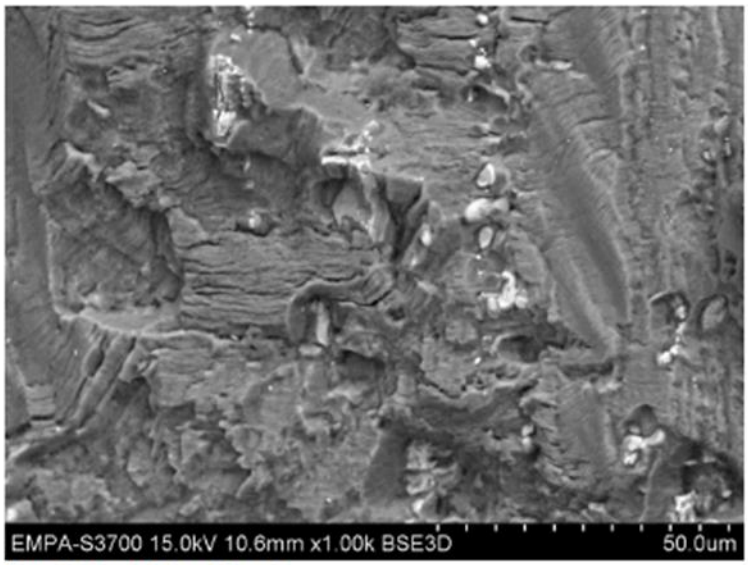

Figure 12: Detailed view of Figure 8

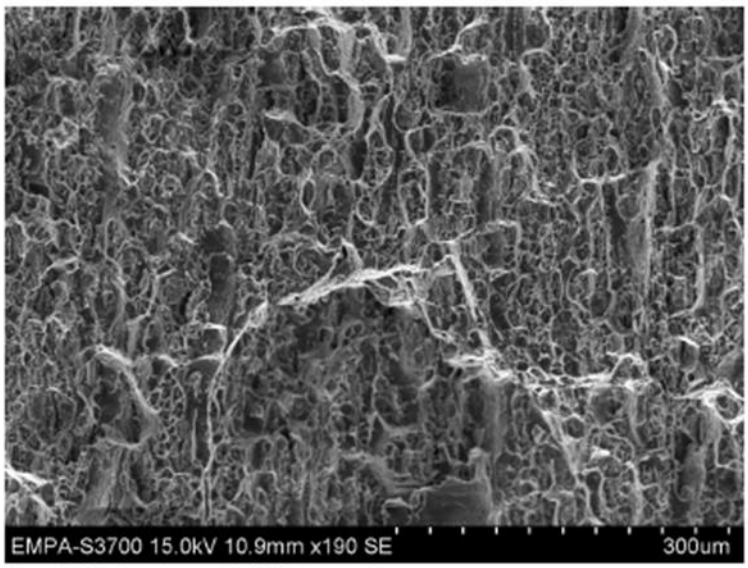

Figure 13: Final rupture on the LH fracture surface

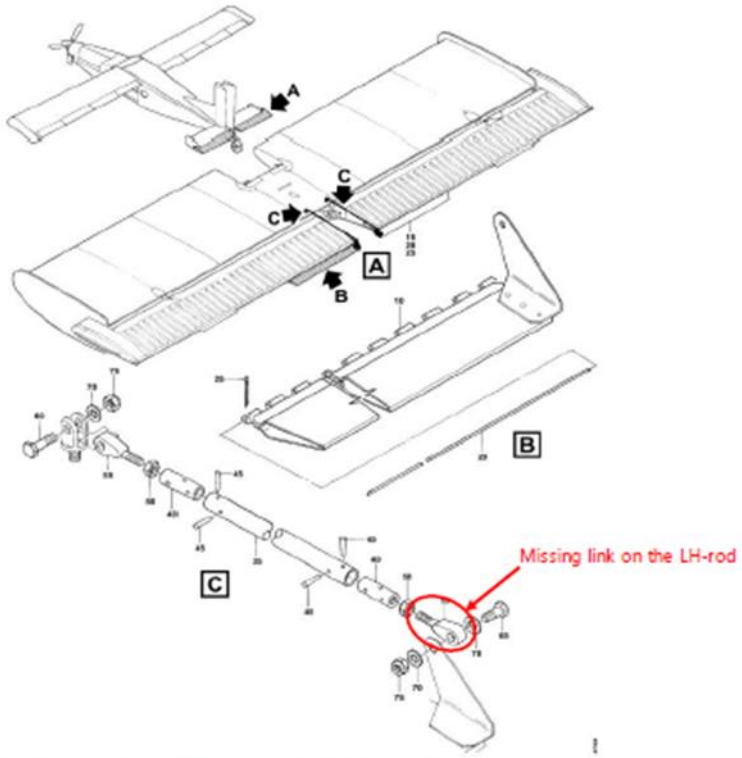

Figure 14: Illustration of the elevator Flettner-Tab Installation (IPC)

Figure 15: LH and RH elevator Flettner-tab as removed from A/C

Figure 16: Condition of the thread at the RH rod (reference)

Figure 17: Condition of the thread at the LH rod

Figure 18: Overview of the LH-wing strut attachment

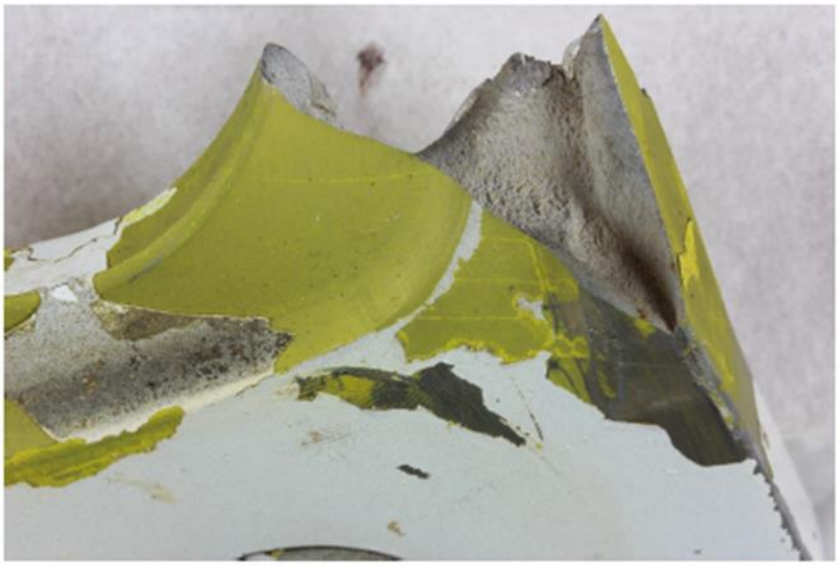

Figure 19: Partially discolored fracture surface before cleaning

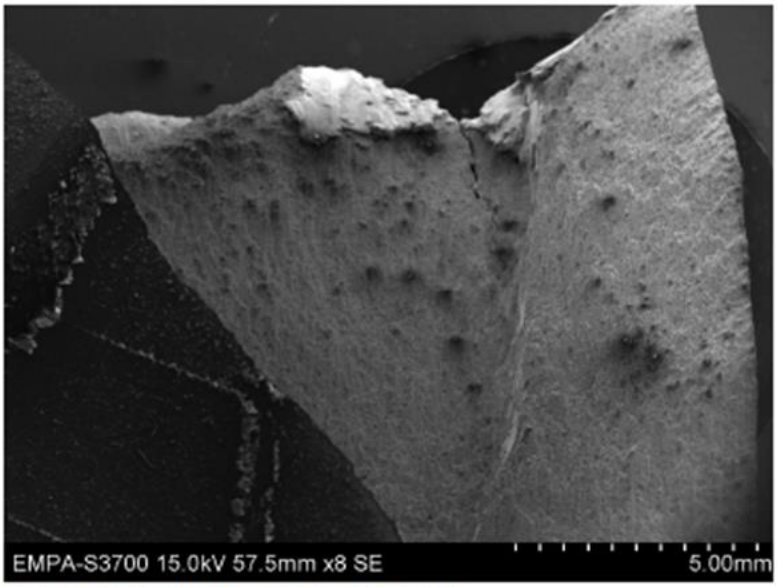

Figure 20: Overview of the fracture after slight cleaning

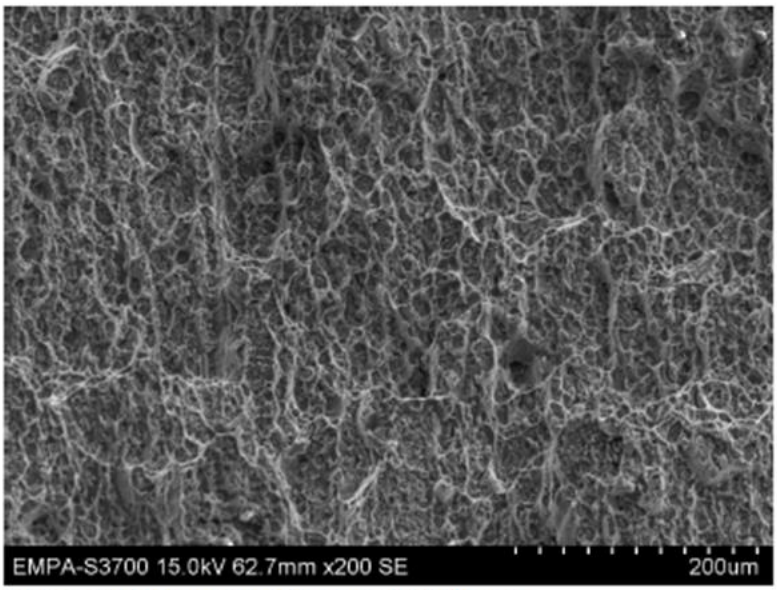

Figure 21: Detailed view of Figure 20 – ductile overload fracture

Apêndice 2 || Appendix 2: Empa - Test Report No 5'214'013'174-3

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Test Report No 5'214'013'174 -3

Test assignment:	**Fractographic Examination of Fuselage Segments from D-FSCB**
Test object:	Segments of the fuselage removed from the Wreckage
Client's ref:	Accident D-FSCB (GPIAA Process 07/ACCID/2016)
Order dated of:	June 27th, 2016
Test object received:	23.11.2016
Test performed:	January - April 2017
Number of pages:	9
Attachments:	

Swiss Federal Laboratories for Materials Science and Technology, Laboratory for Joining Technologies and Corrosion
Dübendorf, 18. May 2017

Principal Investigator:	Technical Supervisor:	Head of Laboratory:
Martin Sauder	Dr. Markus Faller	Dr. Lars Jeurgens

Note: The test results are valid solely for the tested object. The use of the test report for advertizing purposes, any reference to it or the publication of excerpts require the approval of the Empa (see Information Sheet). Test reports and supporting documents are retained for 10 years.

Content

1 Introduction

This is the 3rd Empa-report relating to the accident of D-FSCB. The parts investigated and documented within the first two reports revealed evidence of fatigue at the horizontal stabilizer trim attachment bracket. It does not fall within the competence of Empa to assess or explain the consequences of these findings or their relevance regarding the accident. The report is an essentially factual document based upon the results from the Empa investigations.

Empa was initially involved into this investigation because the first indications (witness reports, crash site appearance) suggested a sudden rupture of the fuselage without an obvious reason.

The ruptured fuselage has been visually inspected during the visit at the GPIAA inspection hangar in Viseu, Portugal. As it is difficult to differentiate between the ductile/fatigue and brittle failure behavior of certain aluminum alloys by eye only, it was decided to closer investigate certain parts of the ruptured fuselage. A total of three fuselage segments were investigated at Empa; the examined results are the content of this report.

2 Investigation

2.1 Received samples

A total of three segments of the fuselage have been received for investigation. Their origin is illustrated in Figure 1. The received parts are illustrated in Figure 2 and Figure 3.

2.2 Visual inspection of the fracture surfaces

All accessible fracture surfaces indicate a 45° shear fracture when visually inspected.

One specific corner of the fuselage (upper right corner – AFT looking FWD) indicated an almost 90° fracture angle of 2 sheets during the inspection of the wreckage in Viseu (Figure 4). This corner is part of sample No. 2 (Figure 5 and Figure 6). It was found that also this area indicates a 45° shear fracture if closer inspected.

2.3 Fractographic investigation

To confirm the interpretation of the visual inspection, the mentioned sheet B and C (referring to Figure 5) were closer investigated, using a scanning electron microscope.

Both sheets show a shear fracture (ductile overload fracture). Even at the corner of the rivet holes, no evidence of fatigue cracking or corrosion can be found (Figure 7-Figure 10).

3 Discussion and Conclusion

It has been found that the fracture surfaces of the fuselage received for this investigation only show ductile overload fracture. No pre-damage or indication of a slow progressing crack growth could be found.

The failure of the investigated fuselage section can be seen as "secondary damage" during the sequence of events.

4 3-D Laser Scans

It has been decided to perform a 3-D laser scan of the samples in their as-received condition. This was primarily meant as an experiment to test this method on such samples in comparison to photographic documentation only. The 3-D scans were carried out by the Forensic Science Institute of the City Police Zürich.

Since a high resolution 3-D scan is difficult to embed into a report, only one specific frame has been added to this report (Figure 6). The greenish colored areas indicate reflective/hidden surfaces. The full resolution original files are stored at the forensic institute.

In our opinion a 3-D scan is very useful when a large area has to be captured in short time (accident site etc.). But even then it is an addition, not a replacement for a decent photographic documentation.

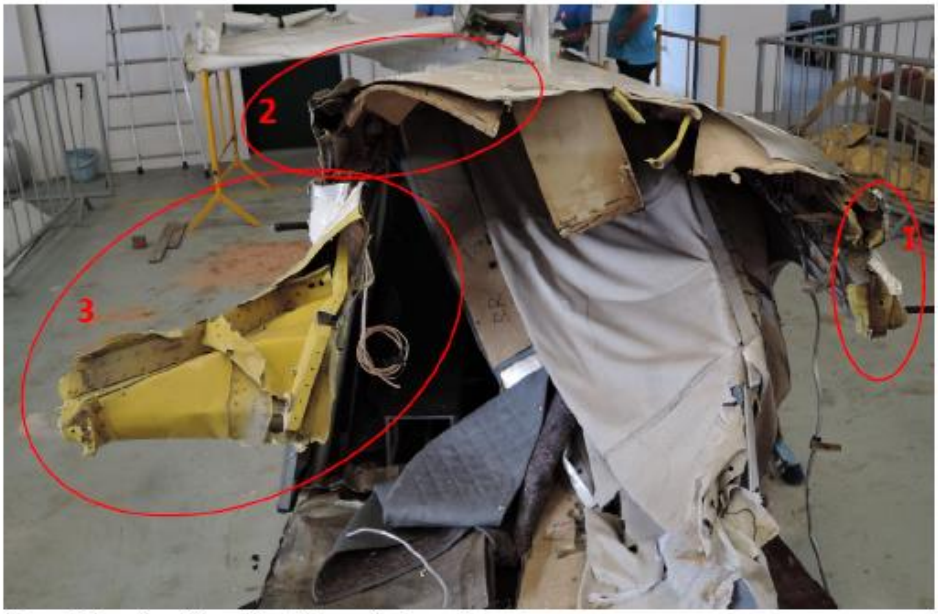

Figure 1: Overview of the origin of the received samples

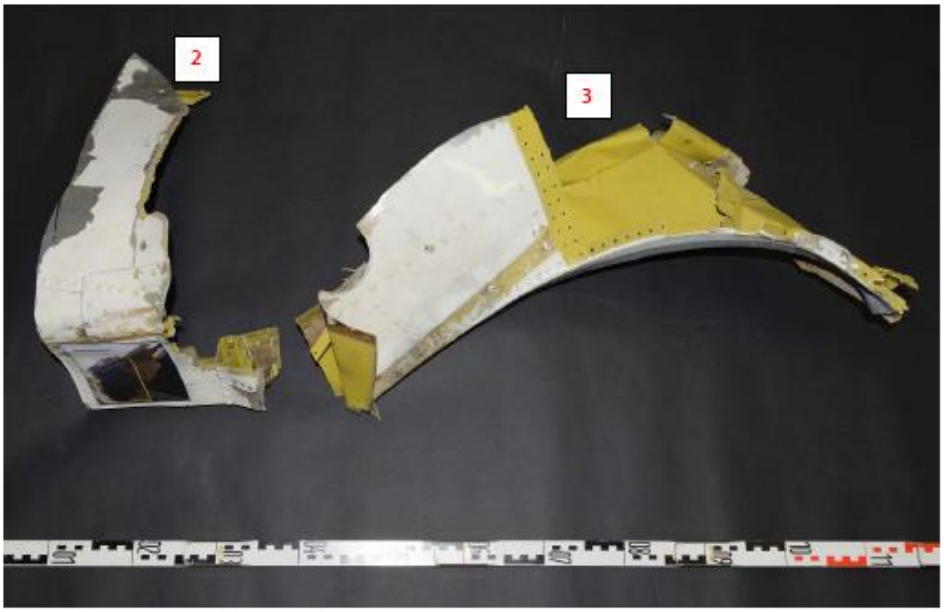

Figure 2: Overview of the samples No. 2+3

Figure 3: Overview of sample No. 1

Figure 4: Appearance of a section of sample no. 2 during the visit in Viseu

Figure 5: Overview of the section indicated in Figure 4

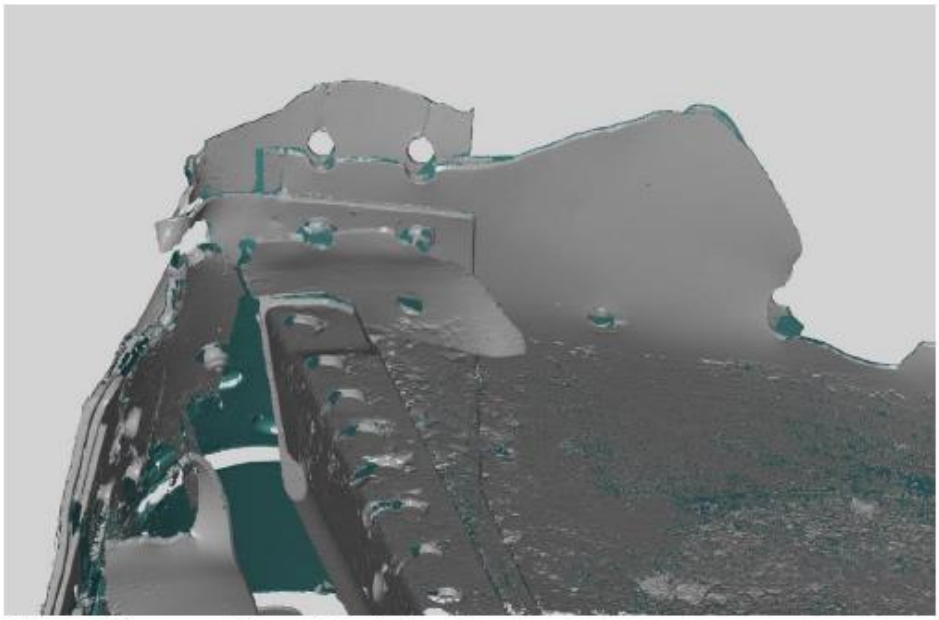

Figure 6: 3-D Laser scan of the area shwon in Figure 5

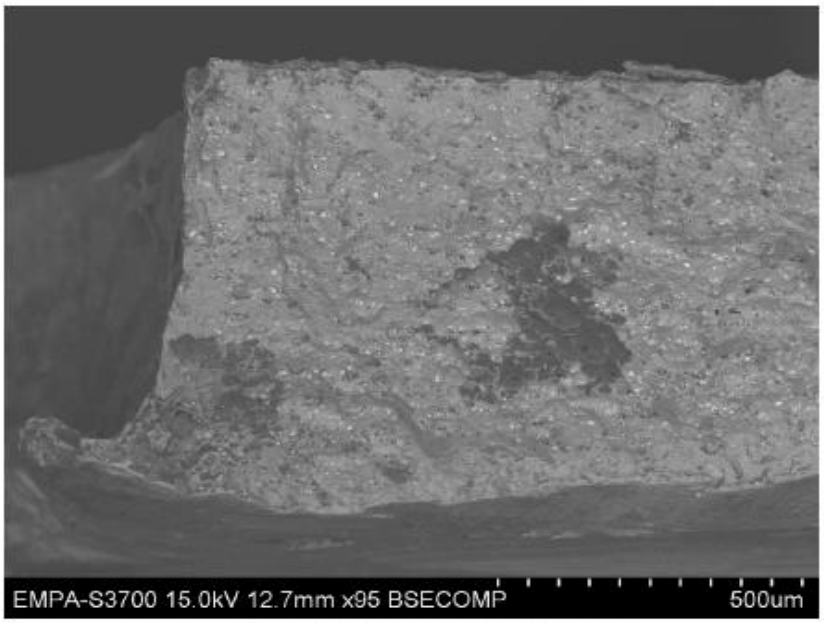

Figure 7: Overview of the fracture surface of sheet no. B at the rivet hole

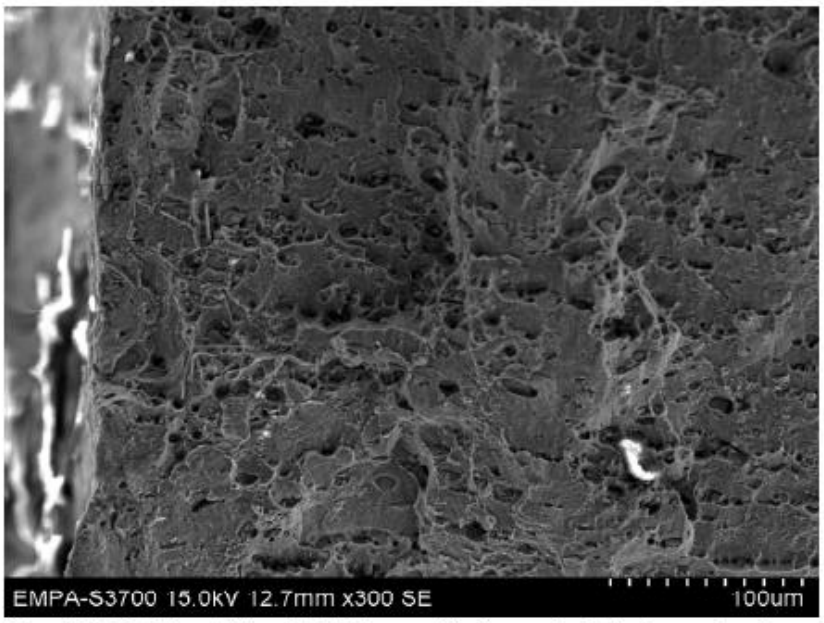

Figure 8: Detailed view of Figure 7 at higher magnification – a dimple fracture can be observed (ductile overload fracture)

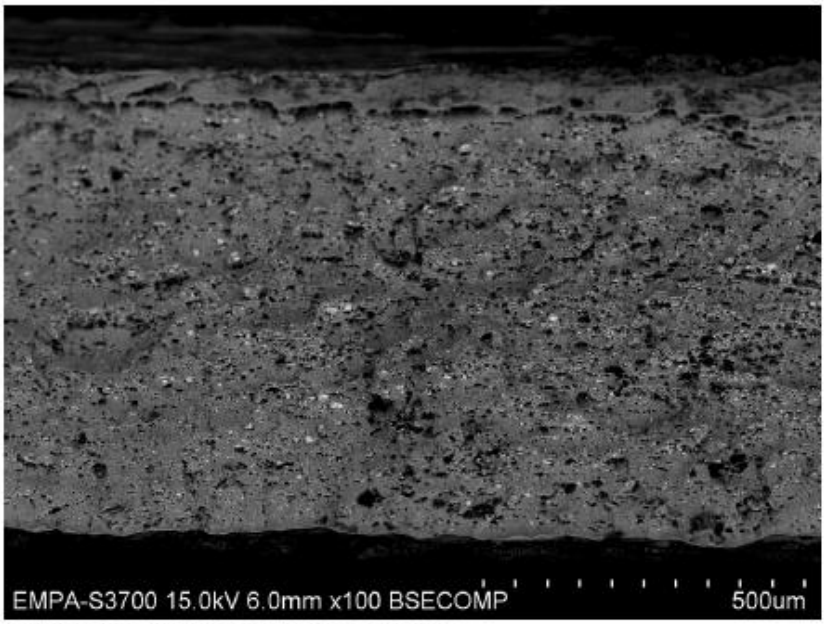

Figure 9: Overview of the fracture surface of sheet C

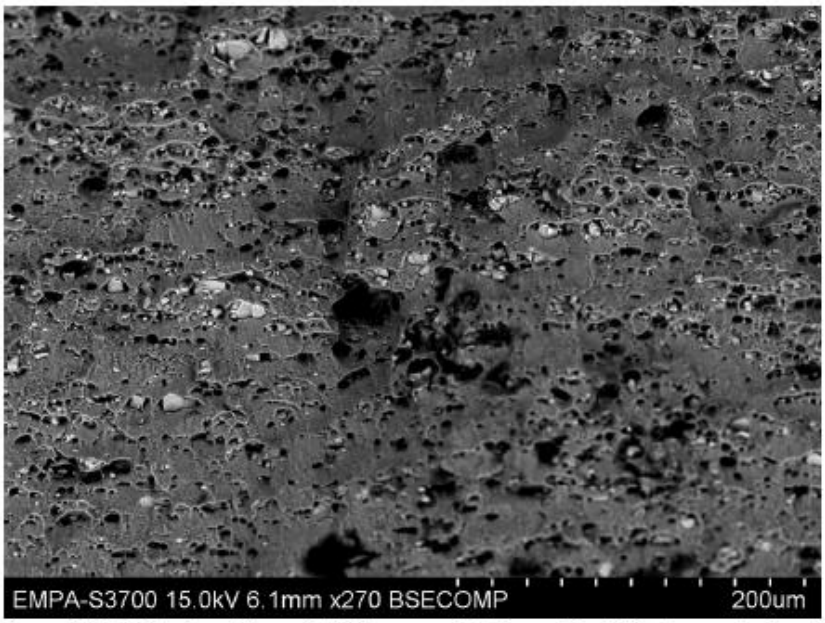

Figure 10: Detailed view of Figure 9 at higher magnification – a dimple fracture can be observed (ductile overload fracture)

Apêndice 3 || Appendix 3: SERVICE BULLETIN NO: 53-003 R1

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PILATUS AIRCRAFT LTD. STANS, SWITZERLAND

SERVICE BULLETIN

PC-6

Service Bulletin No:	**53-003**	**Ref No:**	**215**
Modification No:	**INSPECTION**	**ATA Chapter:**	**53**

FUSELAGE - REAR FUSELAGE
STABILIZER-TRIM ATTACHMENT COMPONENTS - INSPECTION

1. Planning Information

A. Effectivity

Pilatus PC-6 Series aircraft MSNs 337 thru 1005.

Fairchild built PC-6 aircraft MSNs 2001 thru 2092.

All PC-6 horizontal stabilizer assemblies, stabilizer control-system fittings, connecting pieces, bearing supports and bearing forks held as spares.

B. Concurrent Requirements

None.

This Service Bulletin applies to the Post SB 53-001 Revision 1 configuration.

C. Reason

(1) Problem

Wear and cracks have been reported in the following Post SB 53-001 R1 stabilizer-trim attachment and structural components:

- Fitting (116.40.06.112) or (116.40.06.033) in aircraft with electrical horizontal-stabilizer control-systems (CONFIG 1 aircraft)
- Connecting piece (6232.0026 - all variants) in aircraft with mechanical horizontal-stabilizer control-systems (CONFIG 2 aircraft).

(2) Cause

It is possible that slightly asymmetric installation and/or operational conditions resulting in strong stabilizer vibration can cause the initiation of cracks.

(3) **Solution**

NOTE: As an alternative to the inspections detailed in (a) and (b) you can replace the non-inspected items. Replacement instead of inspection satisfies the requirements of this Service Bulletin.

(a) Before the next flight:

Do a visual inspection for crack damage in the applicable stabilizer-trim attachment components, and the related parts and structure. The stabilizer-trim actuator and the fitting or connecting piece must be removed to do the inspection. No cracks are permitted. Replace all crack damaged components and structure before the next flight.

NOTE: If the fitting or connecting piece has been in service for not more than 100 flight hours and not more than 100 landings at the issue date of this SB, the visual inspection before next flight is not necessary.

(b) Within 100 flight hours or 100 landings (whichever comes first):

(i) Do a visual inspection for crack damage in the applicable stabilizer-trim attachment components, and the related parts and structure. No cracks are permitted. Replace all crack damaged components before the next flight.

(ii) Remove the surface finish and do a dye-penetrant inspection for crack damage in the applicable stabilizer-trim attachment components, and the related parts and structure. No cracks are permitted. Replace all crack damaged components before the next flight.

NOTE: As an alternative to the dye-penetrant inspection you can do an eddy current inspection, which does not require removal of the surface finish. A right-angled shaft surface-probe with minimal drop is required to inspect in the gap between the lugs of the components:
- CONFIG 1 aircraft - smallest gap is 12,7 mm (0.5 in.).
- CONFIG 2 aircraft - smallest gap is 6 mm (0.24 in.).

(c) Before installation on an aircraft or within 6 months (whichever comes first):

(i) Do the inspection, detailed in Para. (3)(b) above, of all PC-6 horizontal stabilizer assemblies held as spares. Replace all crack damaged components before installation on an aircraft.

(ii) Do the inspection, detailed in Para. (3)(b) above, of all PC-6 stabilizer control-system fittings, connecting pieces, bearing supports and bearing forks held as spares. Discard all crack damaged parts.

PILATUS

SERVICE BULLETIN

PC-6

D. Description

This Service Bulletin gives the data and instructions to do inspections for crack damage in the applicable stabilizer-trim attachment components and to replace defective components (if necessary).

Revision 1 is issued to:

- Show the screw (16), washer (17) and nut (18) on Fig. 1 and include them in the parts lists and procedures
- Correct two cross-references on Page 10 and correct the SB reference in the title of Fig. 2.

If operators have replaced the bearing fork (Fig. 1, Item 12) in accordance with the initial issue of this Service Bulletin, they must make sure it is installed with two bolts and one screw.

E. Compliance

Mandatory.

The visual inspection is required before the next flight, if:

- The fitting (on CONFIG 1 aircraft) P/N 116.40.06.112 or 116.40.06.033 has been in service for more than 100 flying hours or 100 landings at the issue date of this Service Bulletin
- The connecting piece (on CONFIG 2 aircraft) P/N 6232.0026 has been in service for more than 100 flying hours or 100 landings at the issue date of this Service Bulletin.

The non-destructive inspection is required within 100 flight hours or 100 landings (whichever comes first) after the issue date of this Service Bulletin.

Horizontal stabilizer assemblies, stabilizer control-system fittings, connecting pieces, bearing supports and bearing forks held as spares are to be inspected before installation on an aircraft or within 6 months (whichever comes first) after the issue date of this Service Bulletin.

F. Approval

The technical content of this Service Bulletin is approved under the authority of DOA No. EASA. 21J. 357.

PILATUS advises Operators/Owners to check with their designated Airworthiness Authorities for any changes, local regulations or sanctions that may affect the embodiment of this Service Bulletin.

G. Copyright and Legal Statements

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SERVICE BULLETIN
PC-6

H. Manpower

	Total (Inspection)		Total (Replacements)	
	CONFIG 1	CONFIG 2	CONFIG 1	CONFIG 2
Preparation	1.0	1.0	-	-
Removal	0.5	0.5	-	-
Inspection A - Visual	0.5	0.5	-	-
Inspection B - NDI	0.5	0.5	-	-
Installation/Replacement of Fitting/ Connecting Piece	1.5	1.5	-	-
Replacement of Bearing Fork/Bearing Supports	-	-	4.0	6.0
Close up	0.5	0.5	-	-
TOTAL MAN-HOURS	**4.5**	**4.5**	**4.0**	**6.0**

NOTE: Man-hours figures do not include the time required to cure sealants and adhesives.

I. Weight and Balance

(1) Weight Change

None.

(2) Moment Change

None.

J. Electrical Load Data

Not changed.

K. Software

Not changed.

L. References

PC-6 aircraft except B2-H2/B2-H4:

- Airworthiness Limitations (AL) Doc. 02334: Appendix E and J.
- Repair and Overhaul Manual (ROM): Chapter 2 and 12.

PC-6 aircraft B2-H2/B2-H4:

- Aircraft Maintenance Manual (AMM) Doc. 01975: 27-45-11, 55-11-11.
- Structural Repair Manual (SRM): 51-00-03. 51-00-05, 51-00-06, 51-00-09.

PILATUS

SERVICE BULLETIN
PC-6

M. Publications Affected

None.

N. Interchangeability of Parts

Not applicable.

Service Bulletin No: 53-003
Rev. No. 1 Date: Oct 13/16

Date: Oct 04/16
Page 5 of 24

PILATUS

SERVICE BULLETIN

PC-6

2. Material Information

A. Material - Price and Availability

No Modification Kit is required for this Service Bulletin.

Operators who require further information and/or Service Bulletin material should contact their Authorized Pilatus Service Center, or:.

PILATUS AIRCRAFT LTD
CUSTOMER SUPPORT MANAGER
CH-6371 STANS
SWITZERLAND

General Aviation:
Tel: + 41 41 619 3333
Fax: + 41 41 619 7311
eMail: SupportPC12@pilatus-aircraft.com

Operators are requested to advise Pilatus Aircraft Ltd, of the Manufacturer's Serial Number (MSN) and the flying hours and landings of aircraft which are affected by this Service Bulletin.

B. Material Necessary for Each Aircraft

NOTE: Part numbers given in this Service Bulletin are correct at the time of approval. Pilatus Aircraft Ltd. reserves the right to change the part numbers as necessary. Part numbers of items delivered are correct when dispatched. This could lead to differences between those part numbers quoted in this Service Bulletin and the delivered parts, if parts are superseded. Operators are requested to check the IPC for delivered parts which differ from those listed in the Service Bulletin Materials List.

(1) Material to be Purchased

Operators must order the following parts as necessary for replacement:

New Part No.	Description	Old Part No.	Qty	Disp. Code	Fig	Item
112.35.06.197 6201.0134	FR12a Assembly	112.35.06.197 6201.0134	1	R	1	N/A
116.40.06.033	Fitting (CONFIG 1)	116.40.06.033	1	R	1	6
116.40.06.034	Bearing Fork (CONFIG 1)	116.40.06.034	1	R	1	12
116.40.06.112	Fitting - Post SB 147 (CONFIG 1)	116.40.06.112	1	R	1	N/A
6232.0026.01	Connecting Piece (CONFIG 2)	6232.0026.01	1	R	1	9
6304.0023.01	Bearing Support (Left) (CONFIG 2)	6304.0023.01	1	R	1	3
6304.0023.02	Bearing Support (Right) (CONFIG 2)	6304.0023.02	1	R	1	2
932.35.14.105	Bolt (NAS6604-5) (CONFIG 2)	932.35.14.105	1	D	1	8

Disposition Codes: D - Discard / N - New / R - Return to Pilatus

New Part No.	Description	Old Part No.	Qty	Disp. Code	Fig	Item
932.35.14.109	Bolt (NAS6604-9) (CONFIG 2)	932.35.14.109	1	D	1	8
6201.0134.11	Washer (CONFIG 2)	6201.0134.11	7	D	1	10
938.07.68.305	Nut (MS21046-4E) (CONFIG 2)	938.07.68.305	2	D	1	11
931.54.41.720	Screw, Pan Head (NFL22271BC030020L) (CONFIG 2)	931.54.41.209	1	D	1	16
938.07.31.103	Nut (3PA108) (CONFIG 2)	938.07.34.100	1	D	1	18
938.71.51.103	Washer (NFL23111CA030) (CONFIG 2)	938.78.13.103	1	D	1	17

Disposition Codes: D - Discard / N - New / R - Return to Pilatus

(2) Operator Supplied Materials (Ref. AMM Doc. 01975, 20-31-00 or AL Doc. 02334, Appendix E)

Material No.	Description	Qty	Remarks
P01-008	Solvent (White Spirit)	A/R	Or approved alternative
P02-020	Scotch-Brite	A/R	
P02-031	Absorbent Paper	A/R	
P04-039	Corrosion Preventative	A/R	CA1000
P07-001	CCC Solution	A/R	
P07-007	Epoxy Primer	A/R	
N/A	Permanent Marker Pen	1	Edding Aerospace Marker 8404 or equivalent

C. Material Necessary for Each Spare

(1) Material to be Purchased

Operators must order the following parts as necessary for replacement:

New Part No.	Description	Old Part No.	Qty	Disp. Code	Fig	Item
116.40.06.034	Bearing Fork (CONFIG 1)	116.40.06.034	1	R	1	12
116.40.06.033	Fitting (CONFIG 1)	116.40.06.033	1	R	1	6

Disposition Codes: D - Discard / R - Return to Pilatus

PILATUS

SERVICE BULLETIN

PC-6

New Part No.	Description	Old Part No.	Qty	Disp. Code	Fig	Item
116.40.06.112	Fitting - Post SB 147 (CONFIG 1)	116.40.06.112	1	R	1	N/A
6304.0023.01	Bearing Support (Left) (CONFIG 2)	6304.0023.01	1	R	1	3
6304.0023.02	Bearing Support (Right) (CONFIG 2)	6304.0023.02	1	R	1	2
6232.0026.01	Connecting Piece (CONFIG 2)	6232.0026.01	1	R	1	9
931.54.41.720	Screw, Pan Head (NFL22271BC030020L) (CONFIG 2)	931.54.41.209	1	D	1	16
938.07.31.103	Nut (3PA108) (CONFIG 2)	938.07.34.100	1	D	1	18
938.71.51.103	Washer (NFL23111CA030) (CONFIG 2)	938.78.13.103	1	D	1	17

Disposition Codes: D - Discard / R - Return to Pilatus

D. Re-identified Parts

Not applicable.

E. Tooling - Cost and Availability

Not applicable.

PILATUS

SERVICE BULLETIN

PC-6

3. Accomplishment Instructions - Aircraft

NOTE: AMM references given are applicable for holders of AMM Doc. 01975.

A. Preparation

(1) Remove the access panel FL2.

(2) CONFIG 1 Aircraft:

(a) Remove the horizontal stabilizer actuator (Ref. AMM 27-45-11 (CONFIG 1), Page Block 401).

(3) CONFIG 2 Aircraft:

(a) Remove the horizontal stabilizer actuator (Ref. AMM 27-45-11 (CONFIG 2), Page Block 401). During this procedure use clamps (or equivalent) to make sure the cables stay in position on the spools of the mechanical actuator and operating mechanism.

(4) Use applicable supports to hold the horizontal stabilizer in a position which gives access to bottom surface.

B. Removal (Ref. Fig. 1)

(1) CONFIG 1 Aircraft:

(a) Remove the nuts (7), washers (5), bolts (4).

(b) Remove the fitting (6) from FR12a.

(c) Record the part marking of the fitting (6) on the Report Form supplied with this Service Bulletin.

(d) Discard the fitting if it has incomplete or missing part marking, unless you can confirm the service history of the fitting from its documentation.

(2) CONFIG 2 Aircraft:

(a) Remove the nuts (11), washers (10), bolts (8) and disassemble the connecting piece (9) from FR12a.

(b) Record the part marking of the connecting piece (9) on the Report Form supplied with this Service Bulletin.

(c) Discard the connecting piece if it has incomplete or missing part marking, unless you can confirm the service history of the connecting piece from its documentation.

C. Inspections (Ref. Fig. 1)

(1) Inspection A - Visual Inspection - Before the next flight:

(a) Remove loose paint if necessary, then use absorbent paper (Material No. P02-031) and the solvent (Material No. P01-008) to clean:

- All surfaces of the fitting (6) or connecting piece (9)
- The surfaces of the bearing fork (12) or bearing supports (2) and (3) to which you have access
- The location on the surface of FR12a where the fitting (6) or connecting piece (9) was installed.

(b) Use a 10x magnifier and bright light to visually examine the following parts for damage, cracks and signs of uneven wear. No damage, cracks or uneven wear is permitted:

- The fitting (6) or connecting piece (9)
- The bearing fork (12) or bearing supports (2) and (3) to which you have access.

If you find uneven wear, contact Pilatus Aircraft Ltd.

(c) Use a 10x magnifier and bright light to visually examine the surface of FR12a where the fitting (6) or connecting piece (9) was installed for damage, cracks and corrosion. No damage or cracks are permitted. Remove surface corrosion if found (Ref. ROM Chap 2 or SRM 51-00-05). Discard the part if less than 90% of the original material thickness remains after removal of the corrosion.

(d) Use internal vernier callipers (or equivalent) to do a check of the actuator attachment hole diameters in the fitting (6) (CONFIG 1) and connecting piece (9) (CONFIG 2). Hole diameters of more than 9,555 mm (0.3762 in.) in the fitting or 16.036 mm (0.631 in.) in the connecting piece are not permitted. Replace defective components (Ref. Table 1 - Component Replacement Data).

(e) Use internal vernier callipers (or equivalent) to do a check of the diameters of the attachment bolt holes in the fitting (6) (CONFIG 1) and FR12a (CONFIG 1). Hole diameters of more than 4,85 mm (0.191 in.) are not permitted. Replace the component if defective. If necessary, also replace FR12a, if the applicable holes for the fitting are out of limits (Ref. Table 1 - Component Replacement Data).

NOTE: If the Post SB 147 oversize bush (P/N 116.40.06.111) is installed, contact Pilatus Aircraft Ltd. for more information.

(f) Use internal vernier callipers (or equivalent instrument) to do a check of the diameters of the attachment bolt holes in the connecting piece (9) (CONFIG 2) and FR12a (CONFIG 2):

- If all of the hole diameters are 6,024 mm (0.23717 in.) or less, continue from Para D, Step (2)(b)
- If one or more of the holes are more than 6,024 mm (0.237 in.) but less than 6,35 mm (0.25 in.), continue from Para D, Step (2)(c)

PILATUS

SERVICE BULLETIN

PC-6

- If one or more holes are 6,35 mm (0.25 in.) or more, replace the connecting piece (9) and/or the FR12a (Ref. Table 1 - Component Replacement Data).

(2) Inspection B - Non-Destructive Inspection (NDI) - Within 100 flight hours or 100 landings (whichever comes first):

(a) Do Inspection A - Visual Inspection (Ref. Para. 3.C.(1)).

NOTE: The following step (b) is only necessary if you will do a dye-penetrant NDI. The eddy current NDI does not require the removal of surface treatment.

(b) Obey the manufacturers instructions and use the solvent (Material No. P01-008), Scotch-Brite (Material No P02-020) and/or non-metal scrapers to remove the layers of paint and protection from:

- All surfaces of the fitting (6) or connecting piece (9)
- The surfaces of the bearing fork (12) or bearing supports (2) and (3) to which you have access
- The location on the surface of FR12a where the fitting (6) or connecting piece (9) was installed.

CAUTION: ONLY PERSONNEL QUALIFIED AND CERTIFIED TO THE APPLICABLE LEVEL II (OR HIGHER) OF NATIONAL AEROSPACE STANDARD NAS 410, EUROPEAN STANDARD EN 4179 OR MIL-STD-410E, OR EQUIVALENT AEROSPACE STANDARD, ARE PERMITTED TO DO THE NDI.

(c) Do a dye-penetrant NDI, or the alternative eddy current NDI, as follows:

NOTE: Refer to Airworthiness Limitations Doc. 02334, Appendix J, or SRM 51-00-09 as applicable for the related inspection procedures.

(i) Do the NDI for cracks in all surfaces of the:

- Fitting (6) or connecting piece (9). Make sure you do a thorough inspection of the critical areas shown on Figure 3
- Bearing fork (12) or bearing supports (2) and (3)
- Applicable area of FR12a.

(ii) No crack damage is permitted. You must replace:

- Cracked components (Ref. Table 1 - Component Replacement Data)
- The two bearing supports (2) and (3) if only one is found cracked
- FR12a if cracks are found.

PILATUS

SERVICE BULLETIN

PC-6

Component	Part No.	Replacement
FR12a Assembly	112.35.06.197 6201.0134	Ref. ROM Chap 2 or SRM 51-00-03
Fitting (CONFIG 1)	116.40.06.033	Ref. Para D, Pre-Drilled
Bearing Fork (CONFIG 1)	116.40.06.034	Ref. Para D
Fitting (CONFIG 1)	116.40.06.112	Ref. Para D, Final Diameter
Connecting Piece (CONFIG 2)	6232.0026.01	Ref. Para D, Pre-Drilled
Bearing Support (Left) (CONFIG 2)	6304.0023.01	Ref. ROM Chap 2 or SRM 51-00-03
Bearing Support (Right) (CONFIG 2)	6304.0023.02	Ref. ROM Chap 2 or SRM 51-00-03

Table 1 - Component Replacement Data

D. Installation/Replacement (Ref. Fig. 1)

(1) Install the fitting on CONFIG 1 aircraft:

NOTE: The following Steps (a) and (b) are not required when using a new fitting P/N 116.40.06.112.

(a) Preparation of removed and inspected fitting:

(i) Obey the manufacturers instructions and apply layers of CCC solution (Material No. P07-001) as necessary to the applicable components and inspection areas (Ref. ROM Chap 12 or SRM 51-00-06).

(ii) Obey the manufacturers instructions and apply layers of primer (Material No. P07-007) and paint as necessary to the applicable components and inspection areas (Ref. ROM Chap 12 or SRM 51-00-06).

(iii) Use a permanent marker pen to re-apply the part markings as recorded during the removal procedure.

(b) Preparation of new fitting P/N 116.40.06.033:

(i) Use a suitable drill and reamer to increase the diameter of the three attachment holes to between 4,820 and 4,832 mm.

(ii) Obey the manufacturers instructions and apply layers of CCC solution (Material No. P07-001) as necessary to the reamed holes (Ref. ROM Chap 12 or SRM 51-00-06).

(c) Obey the manufacturers instructions and apply layers of corrosion preventative (Material No. P04-039) on the faying surfaces of FR12a and the fitting (6), nuts (7), washers (5) and bolts (4).

(d) Put the fitting (6) in position on FR12a and install the bolts (4), washers (5) and nuts (7).

PILATUS

SERVICE BULLETIN

PC-6

(e) Obey the manufacturers instructions and use the solvent (Material No. P01-008) to remove unwanted corrosion preventative.

(2) Install the connecting piece on CONFIG 2 aircraft:

NOTE: The following Step (a) is required when using a new connecting piece P/N 6232.0026.01.

(a) Preparation of a new connecting piece P/N 6232.0026.01:

(i) Use a suitable drill and reamer to increase the diameter of the two attachment holes to between 6,000 and 6,012 mm.

(ii) Obey the manufacturers instructions and apply layers of CCC solution (Material No. P07-001) as necessary to the reamed holes (Ref. ROM Chap 12 or SRM 51-00-06).

(b) Do the subsequent steps if all of the hole diameters are 6,024 mm (0.23717 in.) or less:

NOTE: The following Steps (i) thru (iii) are required only when using the removed and inspected connecting piece.

(i) Obey the manufacturers instructions and apply layers of CCC solution (Material No. P07-001) as necessary to the applicable components and inspection areas (Ref. ROM Chap 12 or SRM 51-00-06).

(ii) Obey the manufacturers instructions and apply layers of primer (Material No. P07-007) and paint as necessary to the applicable components and inspection areas (Ref. ROM Chap 12 or SRM 51-00-06).

(iii) Use a permanent marker pen to re-apply the part markings as recorded during the removal procedure.

(iv) Obey the manufacturers instructions and apply layers of corrosion preventative (Material No. P04-039) on the faying surfaces of FR12a and the connecting piece (9), bolts (8), washers (10) and nuts (11).

(v) Put the connecting piece (9) in position on FR12a and install the bolts (8), washers (10) and nuts (11).

(vi) Obey the manufacturers instructions and use the solvent (Material No. P01-008) to remove unwanted corrosion preventative.

(c) Do the subsequent steps if one or more of the holes are more than 6,024 mm (0.237 in.) but less than 6,35 mm (0.25 in.).

(i) Use a 6,35 mm (0.25 in.) (H7) reamer to increase the diameters of the bolt holes. Make sure there are no sharp edges.

(ii) Obey the manufacturers instructions and apply layers of CCC solution (Material No. P07-001) as necessary to the applicable components and inspection areas and the surfaces of the bolt holes (Ref. ROM Chap 12 or SRM 51-00-06).

(iii) Obey the manufacturers instructions and apply layers of primer (Material No. P07-007) and paint as necessary to the applicable components and inspection areas (Ref. ROM Chap 12 or SRM 51-00-06).

(iv) Use a permanent marker pen to re-apply the part markings as recorded during the removal procedure.

(v) Obey the manufacturers instructions and apply layers of corrosion preventative (Material No. P04-039) on the faying surfaces of FR12a and the connecting piece (9), bolts (8) (NAS6604-5 and -9), washers (10) and nuts (11) (MS21046-4E).

(vi) Put the connecting piece (9) in position on FR12a and install the longer bolt (8) (NAS6604-9) in the top hole and the shorter bolt (8) (NAS6604-5) in the lower hole. For each bolt (8) install one washer (10) under the head of the bolt and one washer (10) under the nut (11).

(vii) Obey the manufacturers instructions and use the solvent (Material No. P01-008) to remove unwanted corrosion preventative.

(3) Replace the bearing fork or bearing supports if necessary (Ref. Fig. 1).

(a) Remove the horizontal stabilizer (Ref. AMM 55-11-11, Page Block 401).

(b) On CONFIG 1 aircraft, remove the bearing fork (12):

(i) Use a suitable drill to remove the rivets that attach the access panel (1) to the bottom skin of the horizontal stabilizer. (Ref. ROM Chap 2 or SRM 51-00-03).

NOTE: Some horizontal stabilizers have two access panels (1).

(ii) Remove the nuts (15) and (18), washers (14) and (17), the bolts (13) and the screw (16) then remove and discard the bearing fork (12).

(iii) Obey the manufacturers instructions and apply layers of CCC solution (Material No. P07-001) as necessary in the rivet holes and on all bare metal surfaces.

(c) Preparation of a new bearing fork (12):

(i) Use a suitable drill and reamer to match drill the third hole in the bearing fork (12) to the existing 3,2 mm hole in the stringer. Use the removed bearing fork as a template.

(ii) Obey the manufacturers instructions and apply layers of CCC solution (Material No. P07-001) as necessary to the reamed hole (Ref. ROM Chap 12 or SRM 51-00-06).

(d) Install the new bearing fork (12).

(i) Obey the manufacturers instructions and apply layers of corrosion preventative (Material No. P07-039) on the faying surfaces of the bearing fork (12) and the adjacent structure. Also do this on the applicable surfaces of the nuts (15) and (18), washers (14) and (17), the bolts (13) and the screw (16).

(ii) Put the bearing fork (12) in position and install the bolts (13), the screw (16), the washers (14) and (17) and the nuts (15) and (18).

(iii) Obey the manufacturers instructions and use the solvent (Material No. P01-008) to remove unwanted corrosion preventative.

(e) On CONFIG 2 aircraft, replace the bearing supports (2) and (3) (Ref. ROM Chap 2 or SRM 51-00-03).

(f) Obey the manufacturers instructions and apply layers of CCC solution (Material No. P07-001) on the faying surfaces of the access panel (1) and adjacent skin.

(g) Put the access panel (1) in position and install rivets (CR3223-4-2) (Ref. ROM Chap 2 or SRM 51-00-03).

(h) Install the horizontal stabilizer (Ref. AMM 55-11-11, Page Block 401).

E. Close up

(1) CONFIG 1 Aircraft:

(a) Install the horizontal stabilizer actuator (Ref. AMM 27-45-11 (CONFIG 1), Page Block 401).

(2) CONFIG 2 Aircraft:

(a) Install the horizontal stabilizer actuator (Ref. AMM 27-45-11 (CONFIG 2), Page Block 401).

(3) Remove all tools and materials. Make sure the work areas are clean.

(4) Install access panel FL2.

F. Reporting Action

(1) Send a report to Pilatus Aircraft Ltd. of the inspection (including nil findings). Use the report form provided in this Service Bulletin.

(2) Return replaced parts to:

Pilatus Aircraft Ltd.
Customer Support General Aviation
Department GC
Ennetburgerstrasse 101
6370 Stans
Tel: +41 41 619 3333

G. Documentation

Make an entry in the Aircraft Logbook that Inspection A and/or B of this Service Bulletin is incorporated.

4. Accomplishment Instructions - Spares

NOTE: AMM references given are applicable for holders of AMM Doc. 01975.

A. Horizontal Stabilizer Assembly (Ref. Fig. 1)

It is not necessary to do this procedure if the horizontal stabilizer assembly held as spare has zero flying hours.

CAUTION: ONLY PERSONNEL QUALIFIED AND CERTIFIED TO THE APPLICABLE LEVEL II (OR HIGHER) OF NATIONAL AEROSPACE STANDARD NAS 410, EUROPEAN STANDARD EN 4179 OR MIL-STD-410E, OR EQUIVALENT AEROSPACE STANDARD, ARE PERMITTED TO DO THE NDI.

(1) Inspection

(a) Do a dye-penetrant inspection, or the alternative eddy current inspection, as follows:

NOTE: The dye-penetrant inspection requires the removal and re-application of surface finish and part markings. Keep a record of the part markings and re-apply using a permanent marker pen. Refer to Airworthiness Limitations Doc. 02334 (Appendix J) or SRM 51-00-09 for the related inspection procedures.

(i) Do inspections for cracks in the bearing fork (12) or bearing supports (2) and (3).

(ii) No crack damage is permitted. Replace defective components (Ref. Para. 4.A.(2). You must replace the two bearing supports (2) and (3) if only one is found cracked.

(2) Replacement

(a) CONFIG 1 Horizontal Stabilizer Assemblies:

(i) Use a suitable drill to remove the rivets that attach the access panel (1) to the bottom skin of the horizontal stabilizer. (Ref. ROM Chap 2 or SRM 51-00-03).

NOTE: Some horizontal stabilizers have two access panels (1).

(ii) Remove the nuts (15) and (18), washers (14) and (17), the bolts (13) and the screw (16) then remove and discard the bearing fork (12).

(iii) Prepare the new bearing fork (12) (Ref. Para. 3.D.(3)(c)).

(iv) Obey the manufacturers instructions and apply layers of CCC solution (Material No. P07-001) as necessary in the rivet holes and on all bare metal surfaces.

(v) Obey the manufacturers instructions and apply layers of corrosion preventative (Material No. P04-039) on the faying surfaces of the new bearing fork (12) and the adjacent structure. Also do this on the applicable surfaces of the nuts (15) and (18), washers (14) and (17), the bolts (13) and the screw (16).

(vi) Put the bearing fork (12) in position and install the bolts (13), the screw (16), the washers (14) and (17) and the nuts (15) and (18).

(vii) Obey the manufacturers instructions and use the solvent (Item No. P01-008 or approved alternative) to remove unwanted corrosion preventative.

(viii) Obey the manufacturers instructions and apply layers of corrosion preventative (Material No. P04-039) as necessary) on the faying surfaces of the access panel (1) and adjacent skin.

(ix) Put the access panel (1) in position and install rivets (CR3223-4-2) (Ref. ROM Chap 2 or SRM 51-00-03).

(b) CONFIG 2 Horizontal Stabilizer Assemblies:

(i) If cracks are found replace the bearing supports (2) and (3) (Ref. ROM Chap 2 or SRM 51-00-03). You must replace the two bearing supports if only one was found defective.

B. Inspection - Stabilizer Control-System Fittings, Connecting Pieces, Bearing Supports and Bearing Forks

It is not necessary to do this procedure if the stabilizer control-system fittings, connecting pieces, bearing supports and bearing forks held as spare have zero flying hours.

CAUTION: ONLY PERSONNEL QUALIFIED AND CERTIFIED TO THE APPLICABLE LEVEL II (OR HIGHER) OF NATIONAL AEROSPACE STANDARD NAS 410, EUROPEAN STANDARD EN 4179 OR MIL-STD-410E, OR EQUIVALENT AEROSPACE STANDARD, ARE PERMITTED TO DO THE NDI.

(1) Do a dye-penetrant inspection, or the alternative eddy current inspection, as follows:

NOTE: The dye-penetrant inspection requires the removal and re-application of surface finish and part markings. Keep a record of the part markings and re-apply using a permanent marker pen. Refer to Airworthiness Limitations Doc. 02334 (Appendix J) or SRM 51-00-09 for the related inspection procedures.

(a) Do inspections for cracks in all stabilizer control-system fittings, connecting pieces, bearing supports and bearing forks.

(b) No crack damage is permitted. Discard all defective parts.

C. Reporting Action

(1) Send a report to Pilatus Aircraft Ltd. of the inspection (including nil findings). Use the report form provided in this Service Bulletin.

(2) Return replaced parts to:

Pilatus Aircraft Ltd.
Customer Support General Aviation
Department GC
Ennetburgerstrasse 101
6370 Stans
Tel: +41 41 619 3333

PILATUS

SERVICE BULLETIN
PC-6

D. Documentation

Make an entry in the spare parts inventory list that this Service Bulletin is incorporated.

PILATUS

SERVICE BULLETIN

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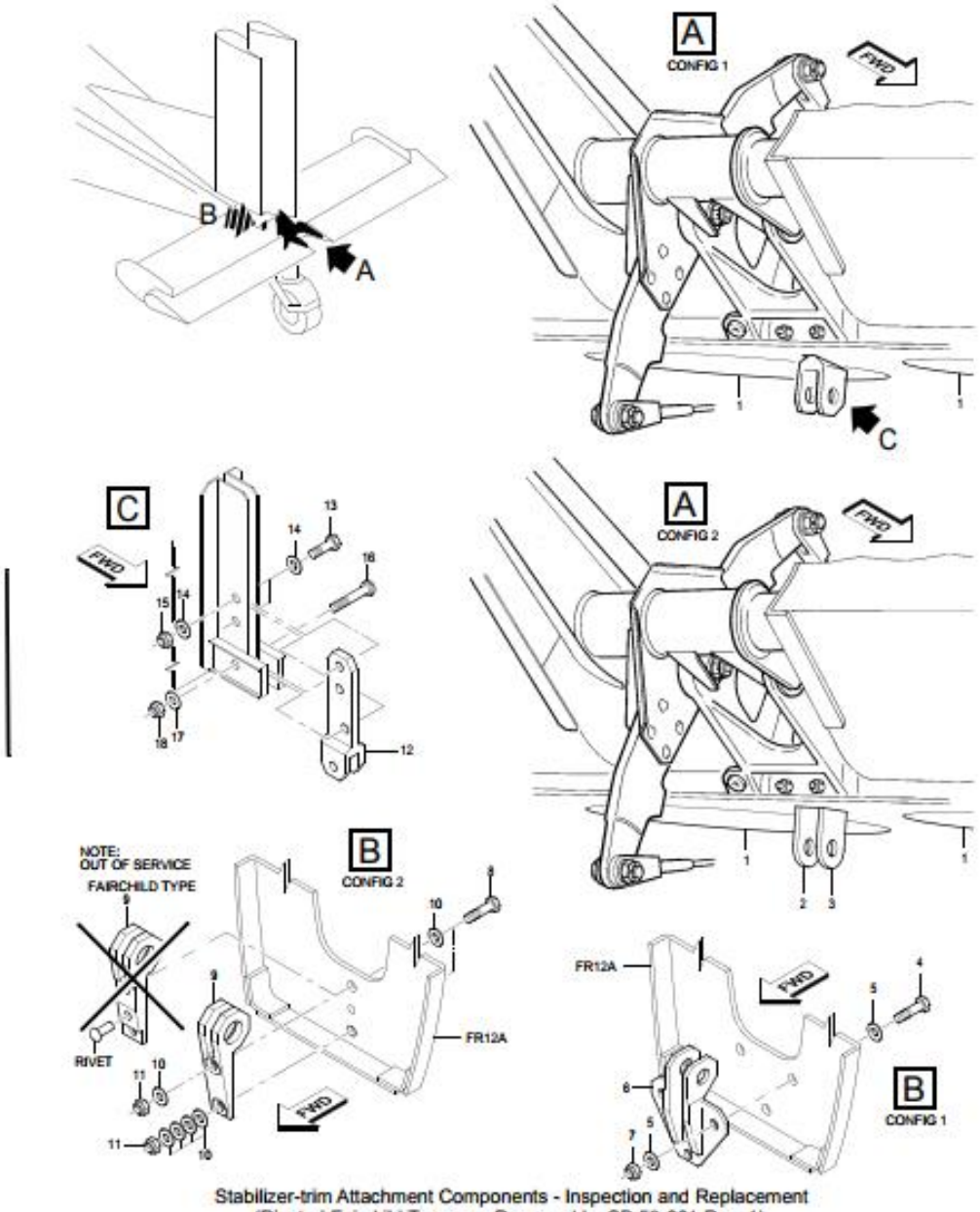


Stabilizer-trim Attachment Components - Inspection and Replacement
(Riveted Fairchild Type was Removed by SB 53-001 Rev. 1)
Figure 1

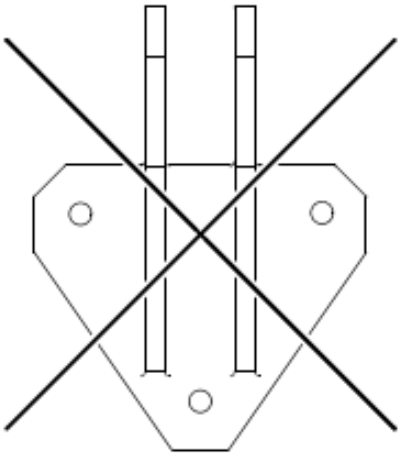
Service Bulletin No: 53-003
Rev. No. 1 Date: Oct 13/16

Date: Oct 04/16
Page 19 of 24

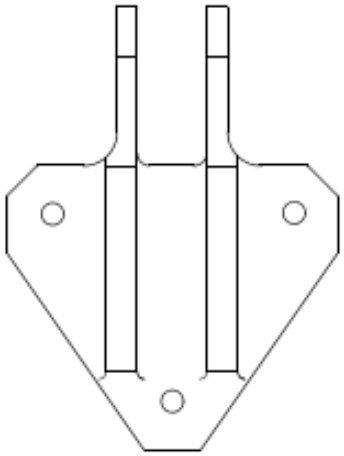
PILATUS

SERVICE BULLETIN

PC-6



WITHOUT INDEX AFTER PART NUMBER



WITH INDEX AFTER PART NUMBER

NOTE: OUT OF SERVICE

169

Difference Between Fittings 116.40.06.033
(Fitting Without Index was Removed by SB 53-001 Rev. 1)
Figure 2

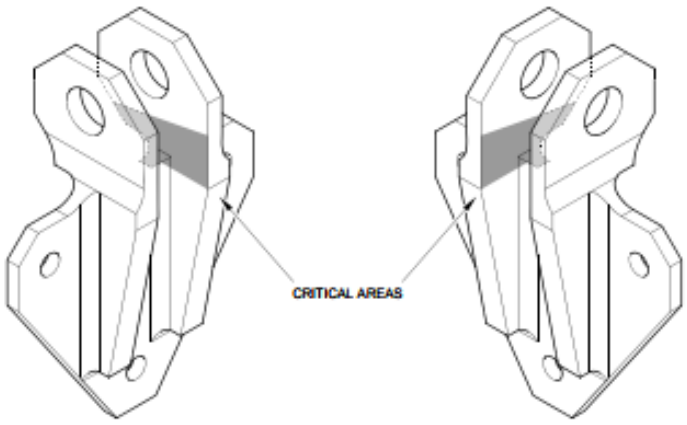
Service Bulletin No: 53-003
Rev. No. 1 Date: Oct 13/16

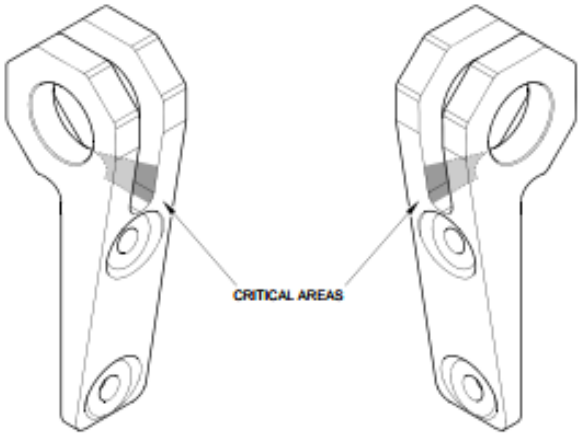
Date: Oct 04/16
Page 20 of 24

PILATUS

SERVICE BULLETIN

PC-6





Critical Inspection Areas
Figure 3

Service Bulletin No: 53-003
Rev. No. 1 Date: Oct 13/16

Date: Oct 04/16
Page 21 of 24

Apêndice 4 || Appendix 4: Empa - Test Report No 5'214'013'174-2

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CH-8600 Dübendorf
T +41 58 765 55 11
F +41 58 765 62 44
www.empa.ch

Empa
Materials Science and Technology

Swiss Transportation Safety
Investigation Board - STSB
Mr. Martin Pohl
Aéropôle 1
1530 Payerne

Test Report No 5'214'013'174 - 2

Test assignment:	**Detailed investigations on the HT-trim fitting removed D-FSCB**
Test object:	HT-trim fitting P/N 116.40.06.033 A
Client's ref:	Accident D-FSCB (GPIAA Process 07/ACCID/2016)
Order dated of:	June 27th, 2016
Test object received:	July 5th, 2016
Test performed:	July-October 2016
Number of pages:	22
Attachments:	Attachment A: Image Gallery
	Attachment B: FT-IR Analysis
	Attachment C: ICP-OES Analysis

Swiss Federal Laboratories for Materials Science and Technology, Laboratory for Joining Technologies and Corrosion
Dübendorf, 28. November 2016

Principal Investigator:	Technical Supervisor:	Head of Laboratory:
Martin Sauder	Dr. Markus Faller	Dr. Lars Jeurgens

Note: The test results are valid solely for the tested object. The use of the test report for advertizing purposes, any reference to it or the publication of excerpts require the approval of the Empa (see Information Sheet). Test reports and supporting documents are retained for 10 years.

Content

1 Introduction

This is a follow-up Report to Empa Test Report No 5214013174, submitted by Empa on September 5th 2016.

During the initial investigation the goal was to identify the fracture mode of several parts removed from the wreckage of D-FSCB. Clear evidence of a fatigue fracture was found in short time on the HT-trim actuator fitting (chapter 2.1 in report no 5214013174).

Because of the potential relevance of this finding, the following investigations have been initiated in coordination with the STSB and Pilatus Aircraft:

- Determination of the **grain-orientation** relevant to the original plate
- Determination of the **surface pre-treatment** prior painting
- Confirmation of correct **alloy and heat treatment**
- Classification of the **foreign material on the fracture surface**
- **Detailed fractographic investigation**, reconstruction of the crack path

2 Investigation

2.1 Metallographic investigation

2.1.1 Grain orientation

In order to determine the grain orientation with respect to the part, microsections in all three planes have been prepared (Figure 1).

The materials used (cold rolled AA2024 plate material) shows an inhomogeneous appearance, if different planes are compared. For better visualization a 3-dimenstion illustration is presented in (Figure 2). The consequent orientation of the part relevant to the original plate is illustrated in (Figure 3). The original micrographs of the 3 different planes can be found in Figure 4 to Figure 9.

To confirm that the part had been correctly heat treated, standard hardness tests were performed. The hardness of the fitting was found to be 139 HV1 or ≈133 HB. This is above the required minimum hardness of 120 HB.

2.1.2 Surface treatment prior painting

The question arose whether the part had seen an alodine or anodization pre-treatment during production. The part has been manufactured within a transition period, where both processes have been in use. In order to achieve an uncontaminated cross-section - this would be important in case of an alodine treatment - the sections have been prepared by Ar-ion cross-section milling.

The prepared cross-sections indicate a uniform oxide layer of about 3 µm thickness (Figure 10). The surface shows etch-pits in areas where precipitations reach the surface. SEM-EDX measurements indicate that the oxide layer consists of aluminum oxide. The mentioned etch pits are uniformly oxidized (Figure 11).

This is the typical appearance of an anodized surface. No indications for a chromium conversion coating (alodine) are present.

2.2 Chemical Analysis

The chemical composition of the base material was determined to confirm conformity with the Al-alloy 2024. A part of the back plate of the fitting was mechanically milled into fine chips for ICP-OES analysis. Prior to that, an ED-XRF measurement was performed as preliminary information. The results of both measurements are listed in the table below. It must be noted that the Fe-content of the ICP-OES analysis is not reliable due to wear of the used drilling tools and or the small amount measured (100 mg each sample). The internal report regarding the ICP-OES analysis can be found in attachment C.

Element	Specified Limits for AA 2024	ED-XRF Analysis	ICP-OES Analysis
Si	<0.50	0.11	0.27 ± 0.00
Fe	<0.50	0.14	0.45* ± 0.38
Cu	3.8-4.9	3.9	3.85 ± 0.06
Mn	0.30-0.9	0.57	0.60 ± 0.01
Mg	1.2-1.8	1.5	1.40 ±0.04
Cr	<0.10	<0.05	0.01 ± 0.00
Zn	<0.25	0.13	0.13 ± 0.00
Ti	<0.15	<0.1	0.03 ± 0.00
Al	base	93.7	base

All measurements indicated that the alloy used is within specified limits.

2.3 Foreign product on the fracture surface

The black contamination on the fractured surface (Figure 12) of the fitting was removed using solvents and analyzed with FT-IR spectroscopy. The spectrum shows evidence of an organic compound which is typically found in lubricants (fatty acid ester).

The best spectrum match within our database (attachment B) indicates a product that is called Span 65. This match cannot be the true component, as Span 65 (also known as E492) is an additive used in the food industry. Nevertheless, the spectrum indicates a typical component of lubricants.

For better identification, more effort on this topic would be necessary.

2.4 Detailed fractographic investigation

In contrast to the initial report, the following investigation has been performed primary on the fuselage side of the fracture. This fracture surface is better preserved (less secondary damage; Figure 14). The fracture surface has been cleaned using ethanol and an ultrasonic bath. With this method, it was not possible to remove all of the contamination (Figure 14 and Figure 21).

The area of fatigue fracture vs. final rupture has been determined on a top-view of the fracture surface (Figure 13).

2.4.1 RH side fracture

An overview of the optical appearance of both RH fracture surfaces is illustrated in Figure 14.

In comparison to optical images, it is possible to "look" through a certain thickness of contamination using an electron microscope at high accelerating voltage (≈15 kV or more). But the loss of details increases dramatically with the thickness and type of contamination. Nevertheless it was possible to identify the area of the crack origin to some accuracy as illustrated in Figure 15 and Figure 16.

The effective spacing between individual fatigue striations is difficult to measure (oxidation). Measurements on the actuator sided, Au-sputtered RH fracture face indicate a value in the range of 50-100 nm mid-fracture. The fracture can be classified as a typical high cycle fatigue (HCF) fracture.

2.4.2 LH side fracture

As already reported, the LH side fracture only contains a relatively small part of fatigue fracture (Figure 13). Due to the observations on the RH fracture, a second look on the LH fracture has been taken in order to optimize the result.

It appears that the fatigue crack at the LH fracture (Figure 21) also started at a specific point, not as initially reported at multiple points. The contamination near the crack origin does not allow a reliable reconstruction of the crack path as on the RH fracture, but all indications point towards the corner indicated in Figure 22 and Figure 23

3 Discussion and Conclusion

The results documented in this report are solely meant to support the accident investigation, and are not intended to explain the nature of the accident. Therefore, we avoid drawing any conclusions towards the accident`s cause or the relevance of the findings in this report.

4 Attachment A: Image Gallery

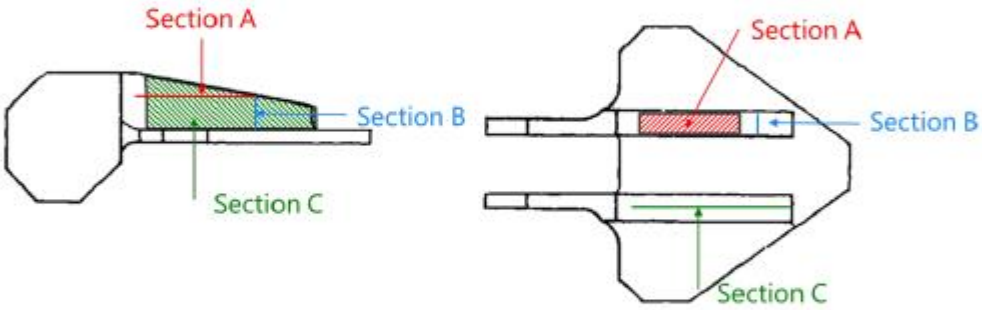

Figure 1: Position and orientation of the prepared microsections

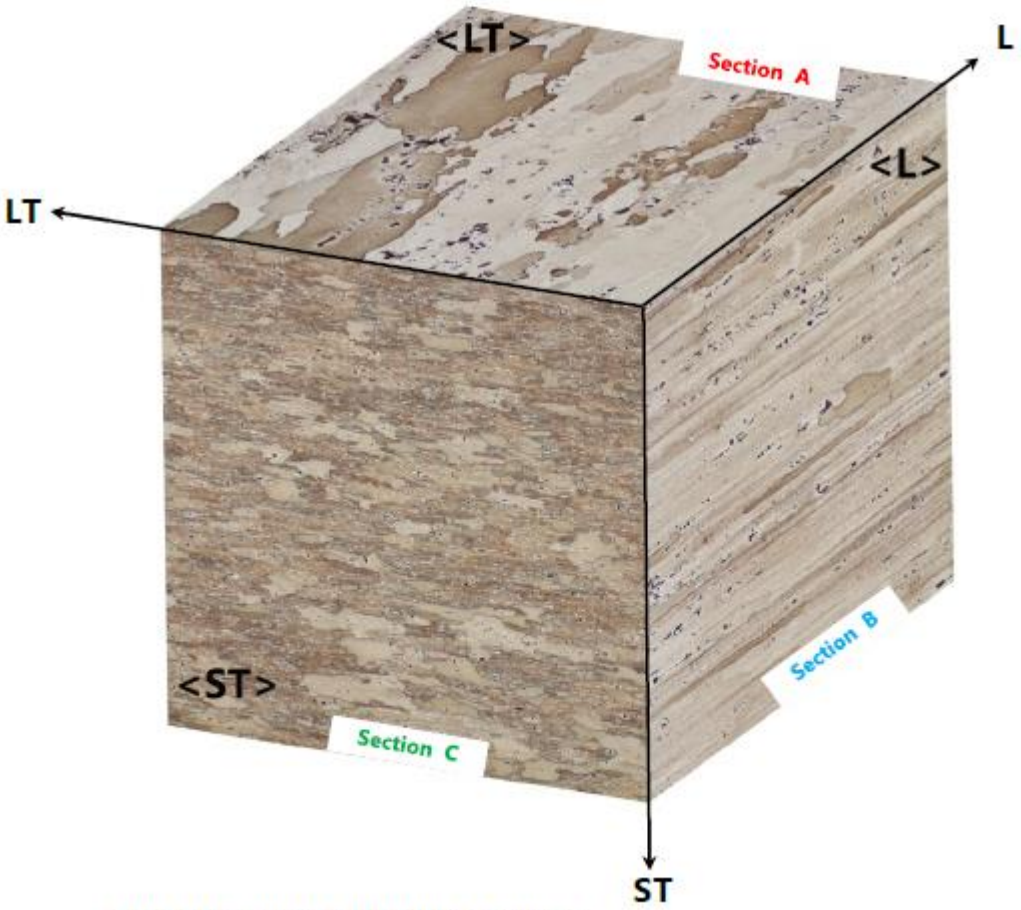

Figure 2: Microstructure of the different sections

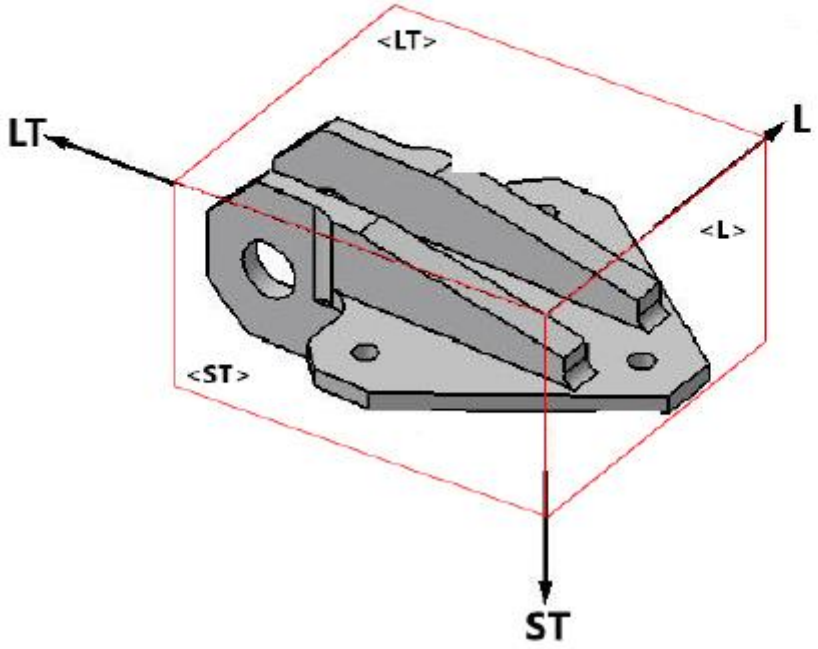

Figure 3: Illustration of how the part is oriented regarding the original plate (referring to Figure 2)

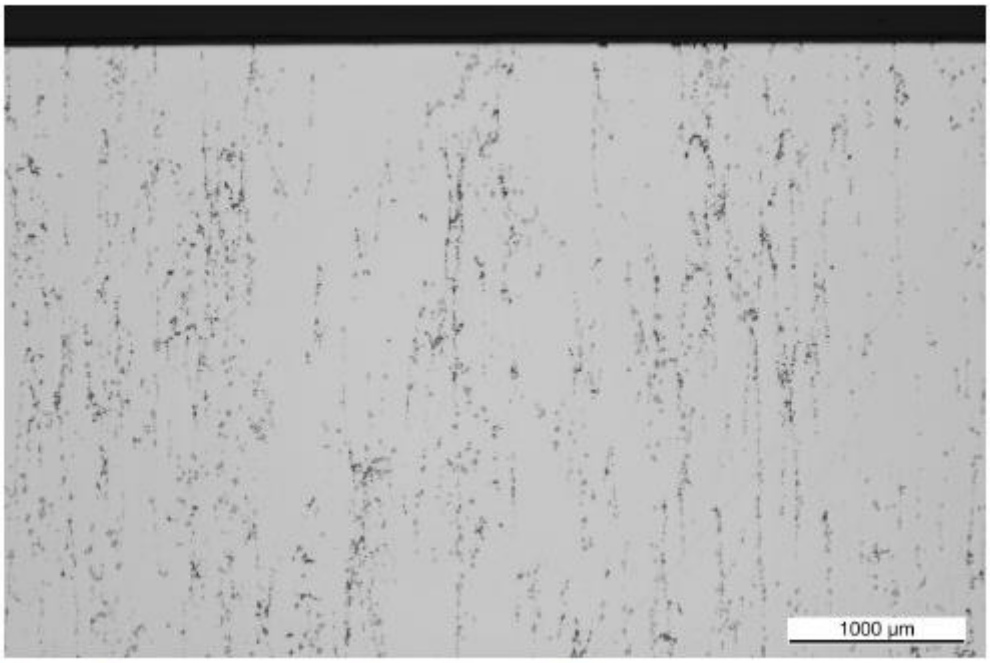

Figure 4: Polished microsection in <LT> direction (section A)

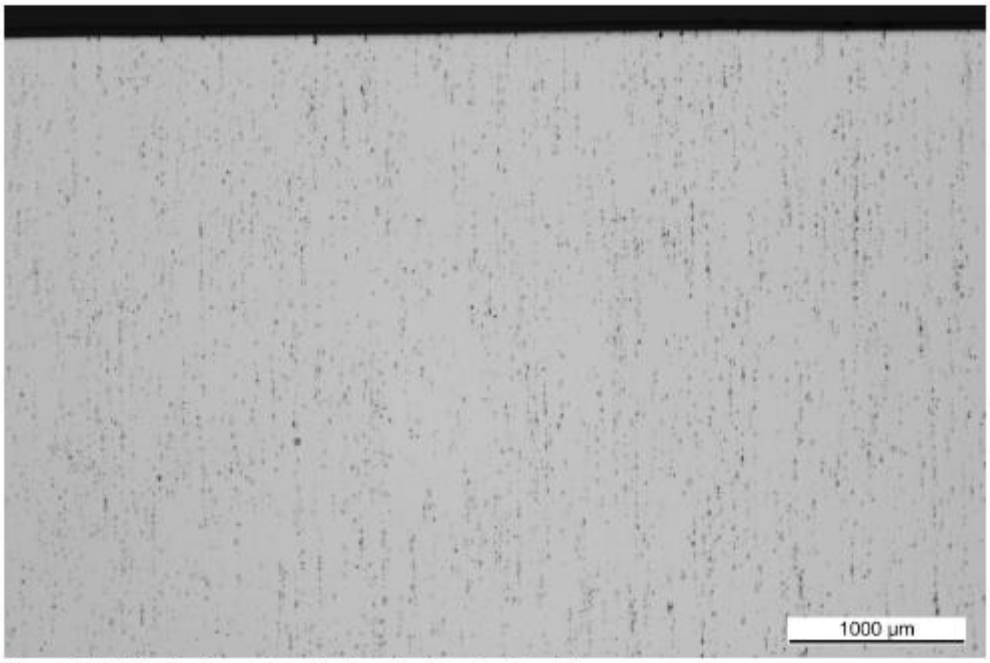

Figure 5: Polished microsection in <L> direction (section B)

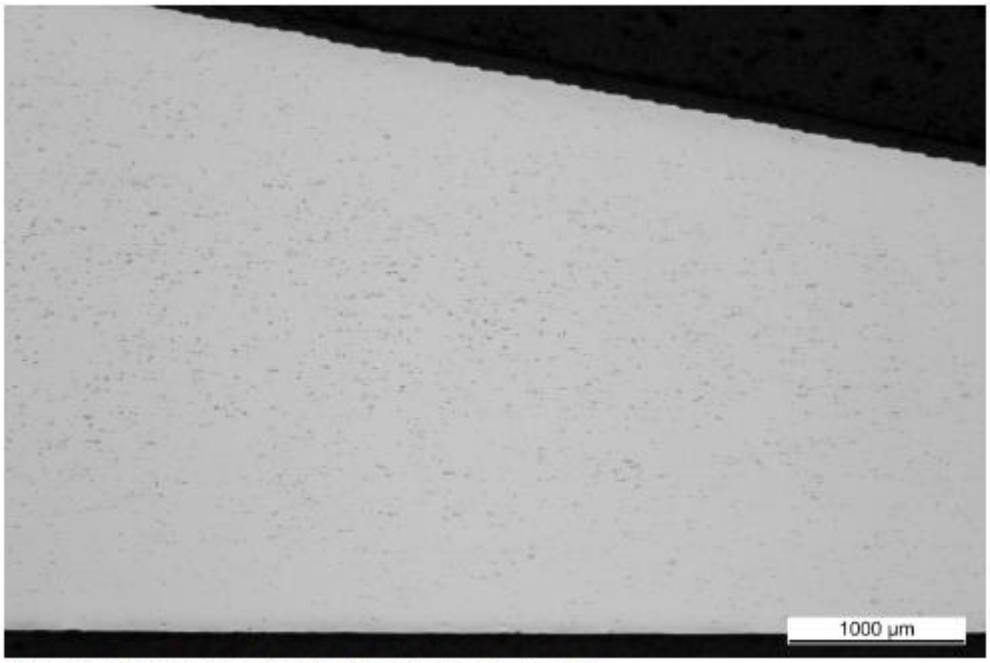

Figure 6: Polished microsection in <ST> direction (section C)

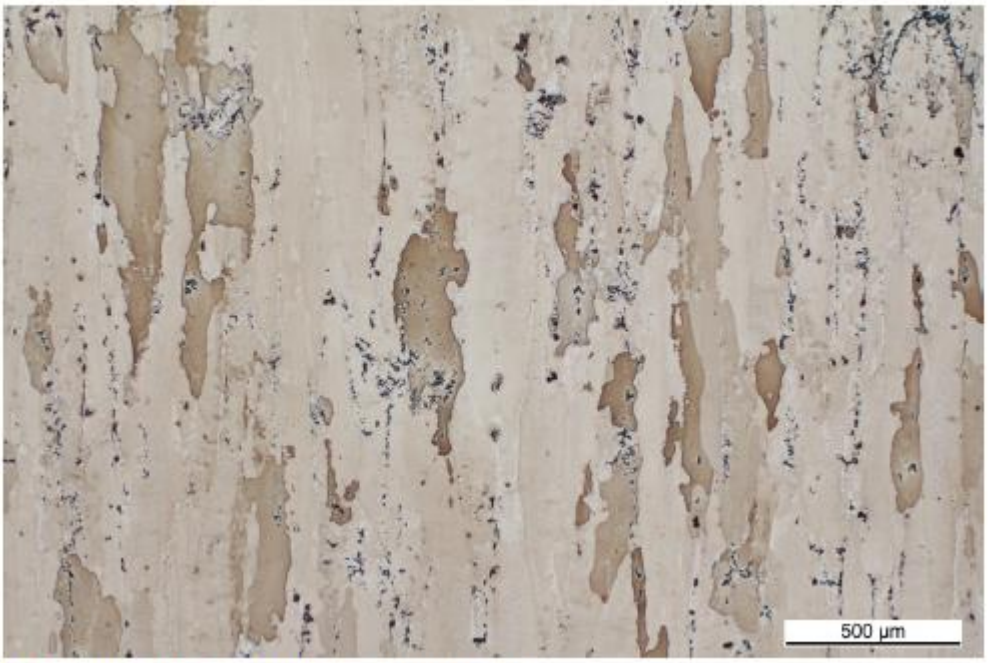

Figure 7: Etched microsection in <LT> direction (section A)

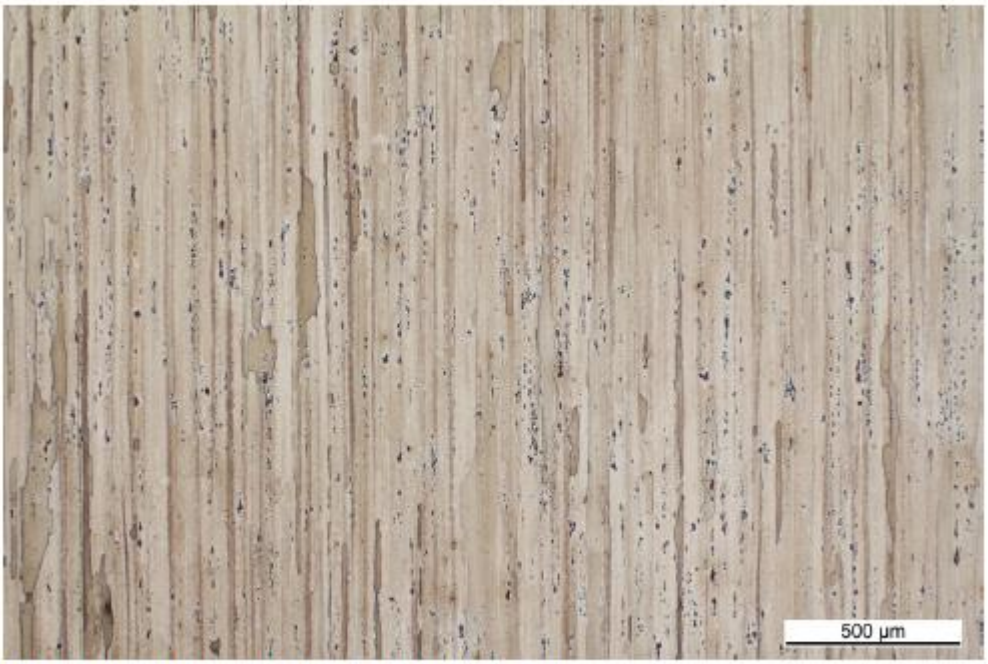

Figure 8: Etched microsection in <L> direction (section B)

Figure 9: Etched microsection in <ST> direction (section C)

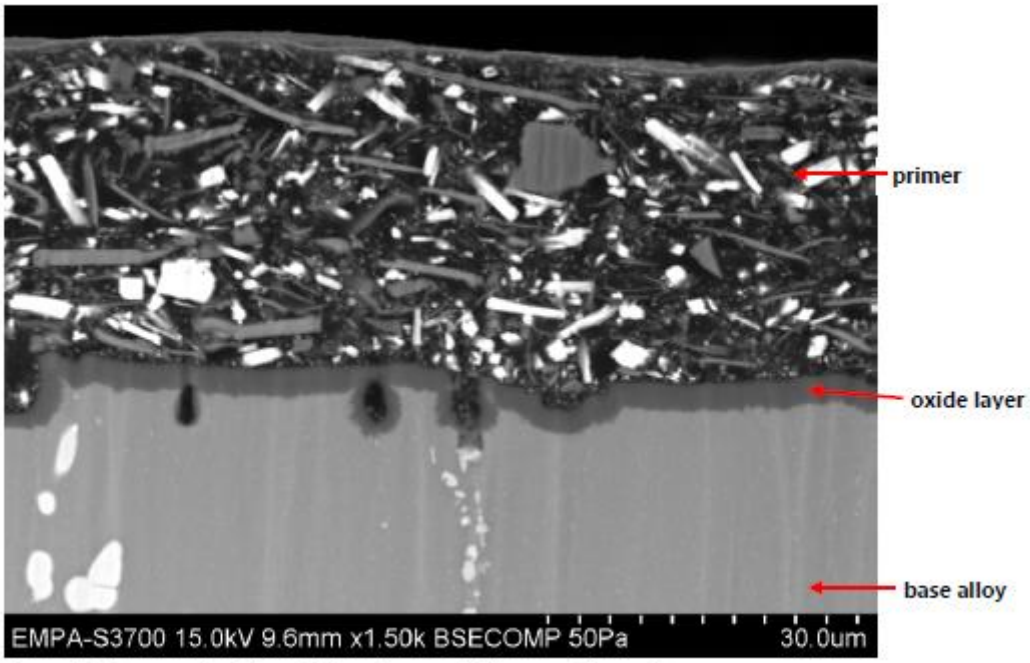

Figure 10: Cross-section through the primer, oxide layer and base alloy

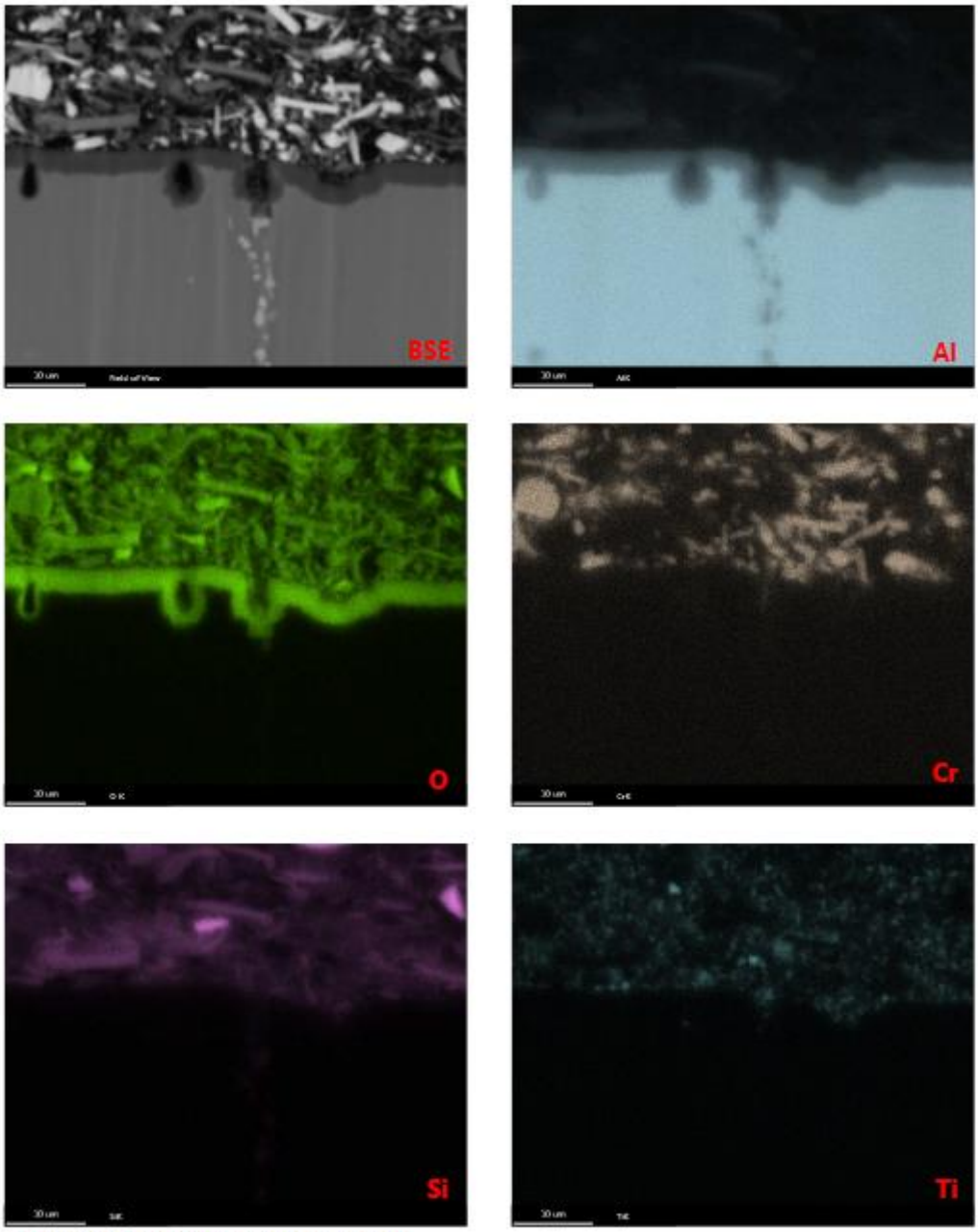

Figure 11: SEM-EDX-Mapping of Figure 10

Figure 12: HT-trim attachment in unchanged condition with black contamination on the fracture

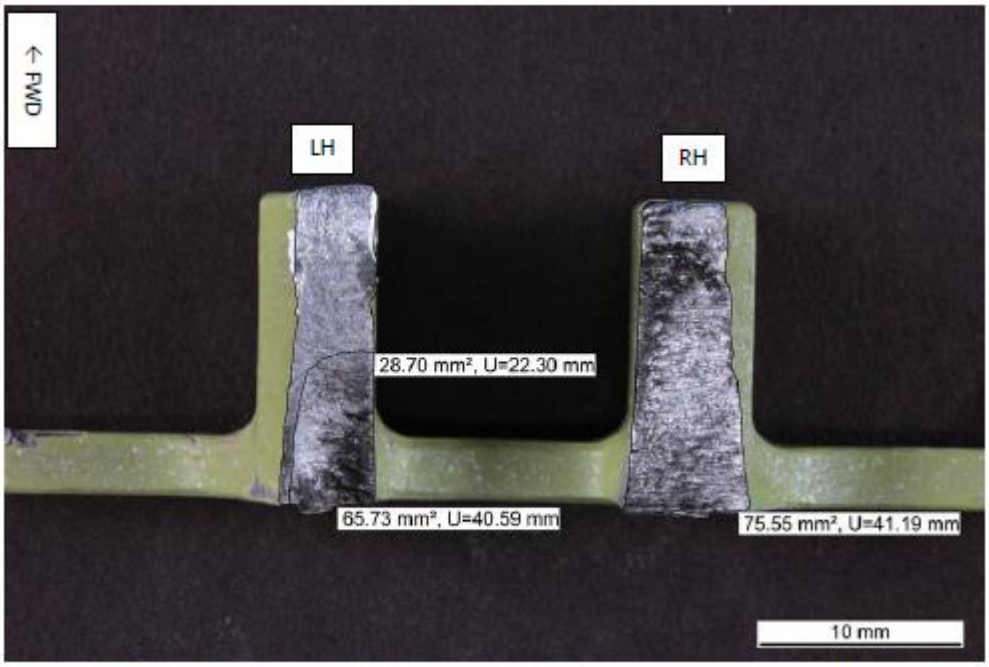

Figure 13: Top-view used to estimate the area of fatigue vs. final rupture – complete fratigue fracture on the RH, about 29 mm^2 fatigue on the LH fracture

Empa, Laboratory: Joining Technologies and Corrosion
Client: Swiss Transportation Safety Investigation Board - STSB, 1530 Payerne

Page 14 / 22
Test Report No 5'214'013'174

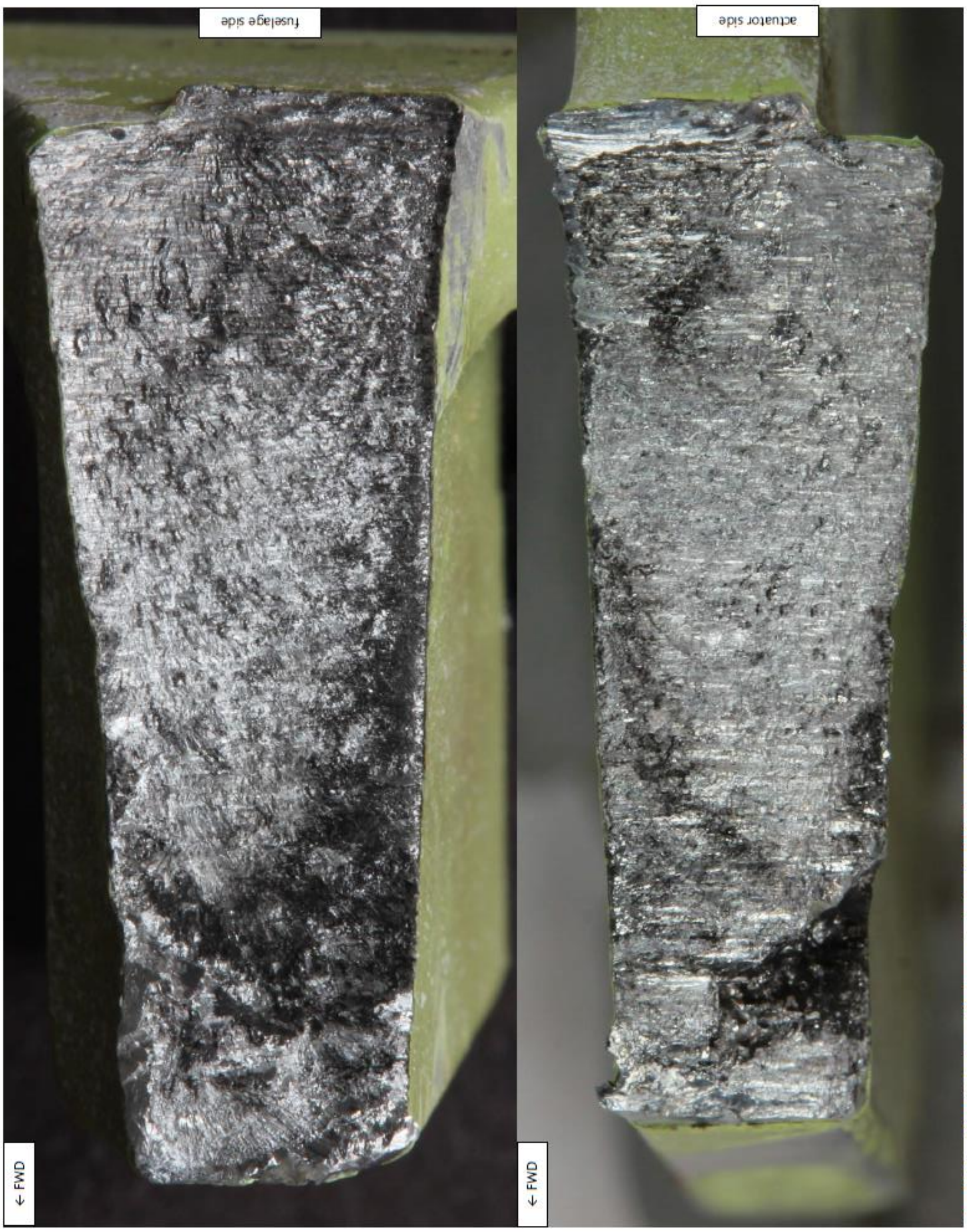

Figure 14: Condition of the cleaned fuselage and actuator side RH fracture surfaces in cleaned condition

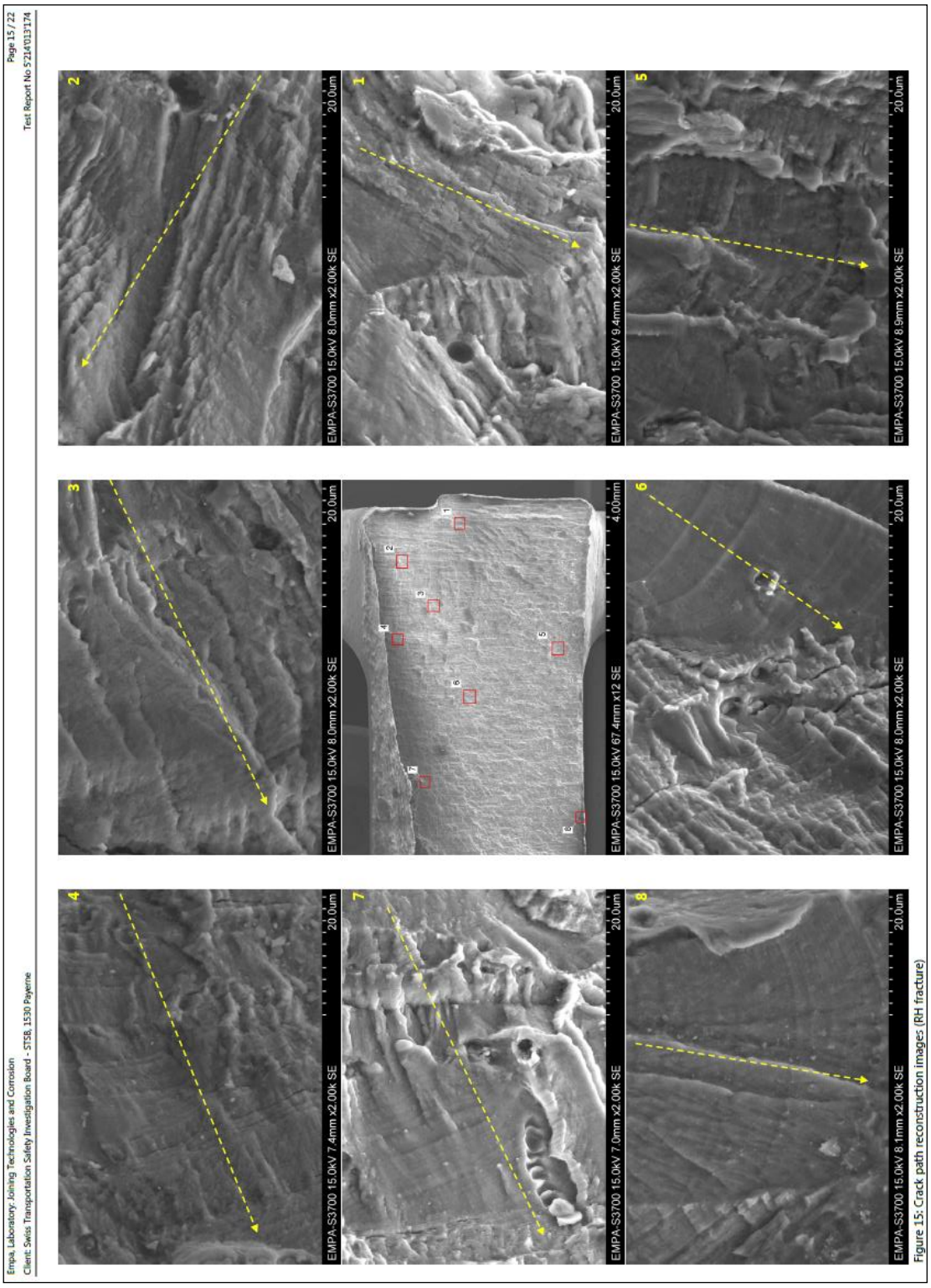

Figure 15: Crack path reconstruction images (RH fracture)

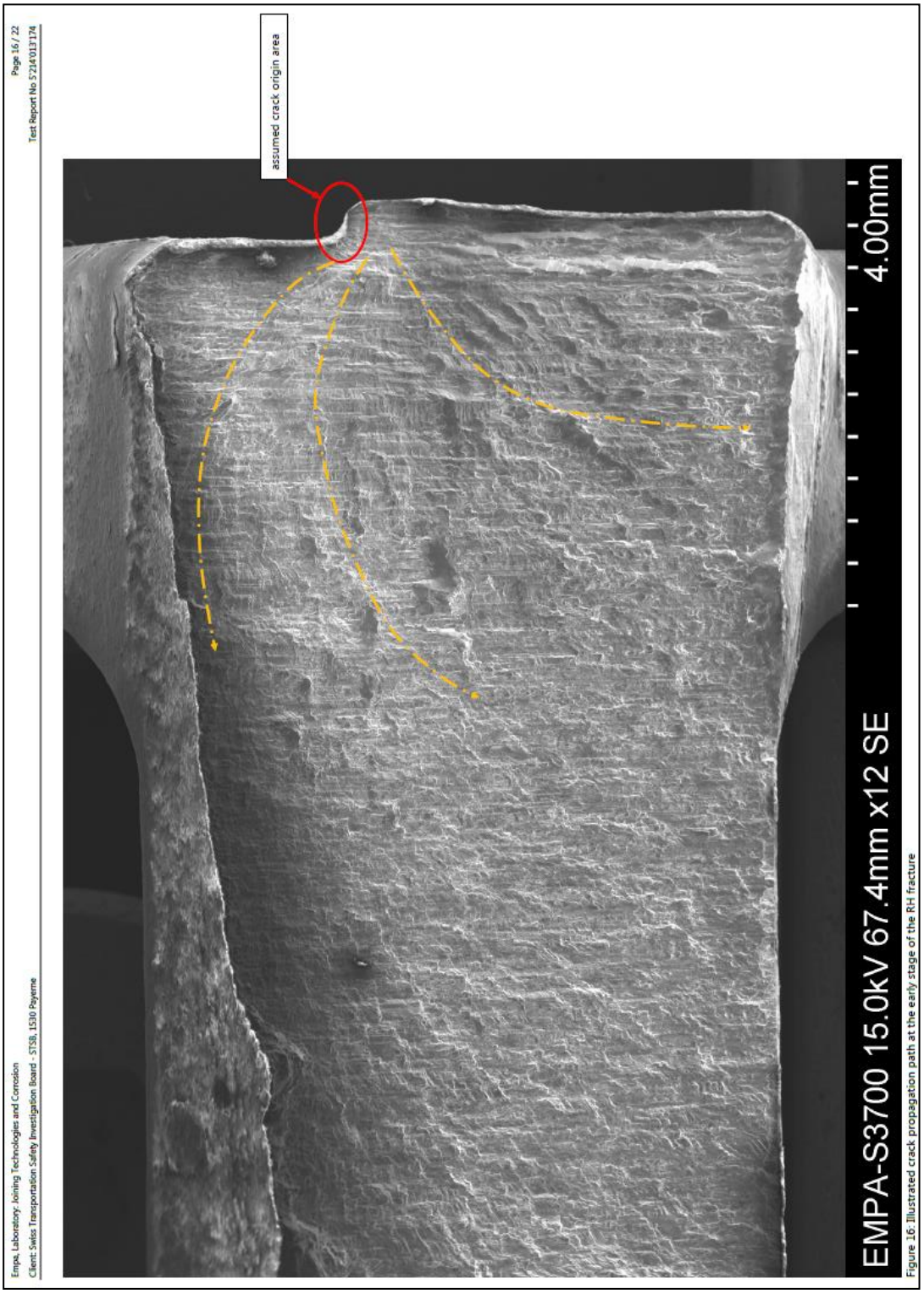

Figure 16: Illustrated crack propagation path at the early stage of the RH fracture

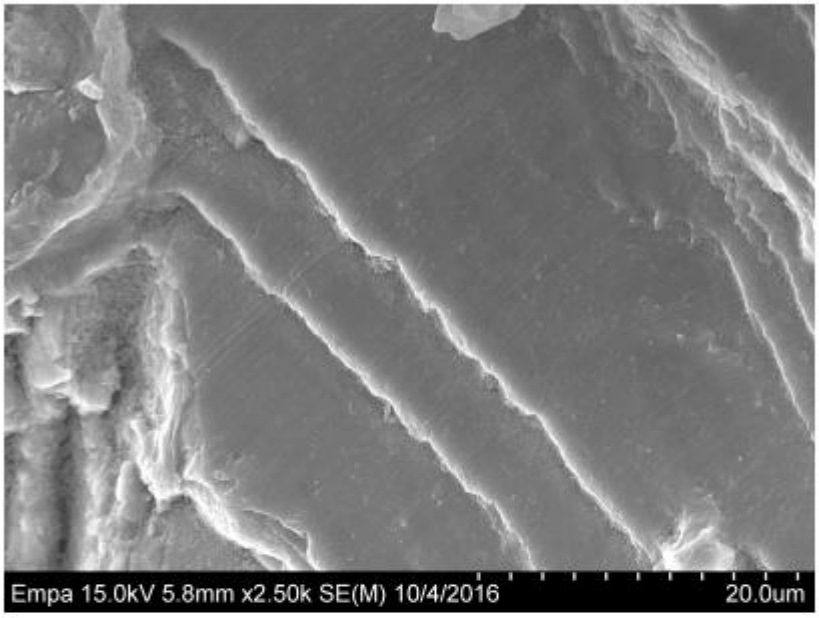

Figure 17: RH fracture (actuator side) - overview

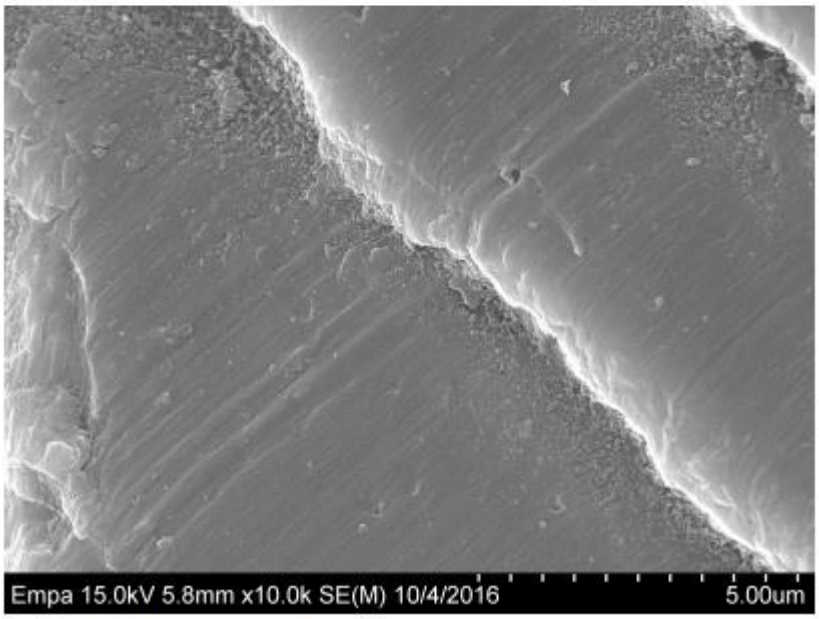

Figure 18: Detaild view of Figure 17

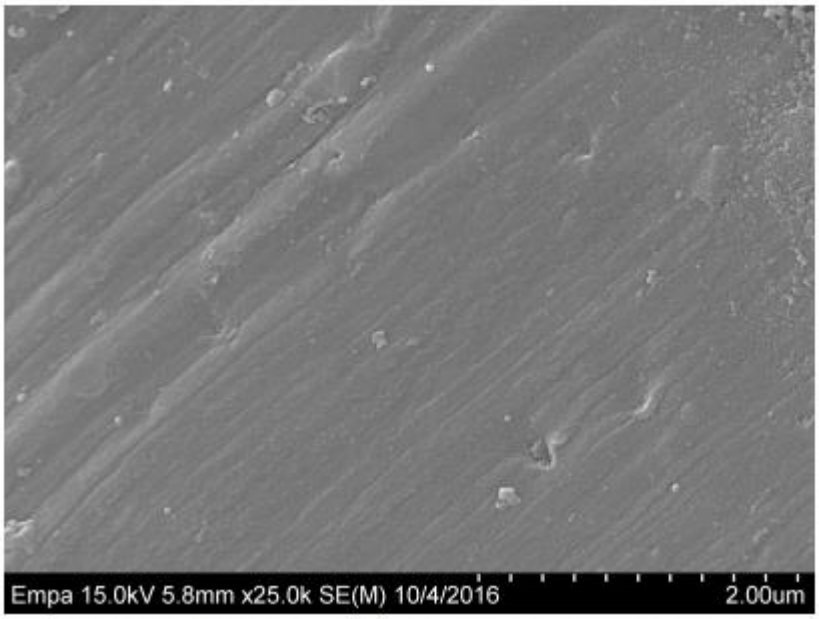

Figure 19: Detaild view of Figure 18; Individual striations are difficult to determine

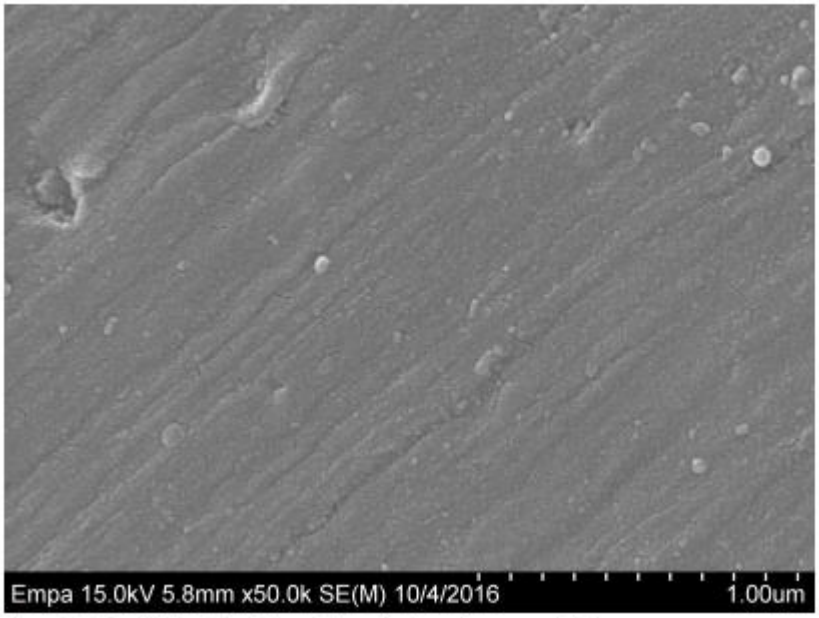

Figure 20: Detaild view from Figure 19; oxide layer becomes visible

Figure 21: Condition of the cleaned fuselage and actuator sided LH fracture surfaces in cleaned condition

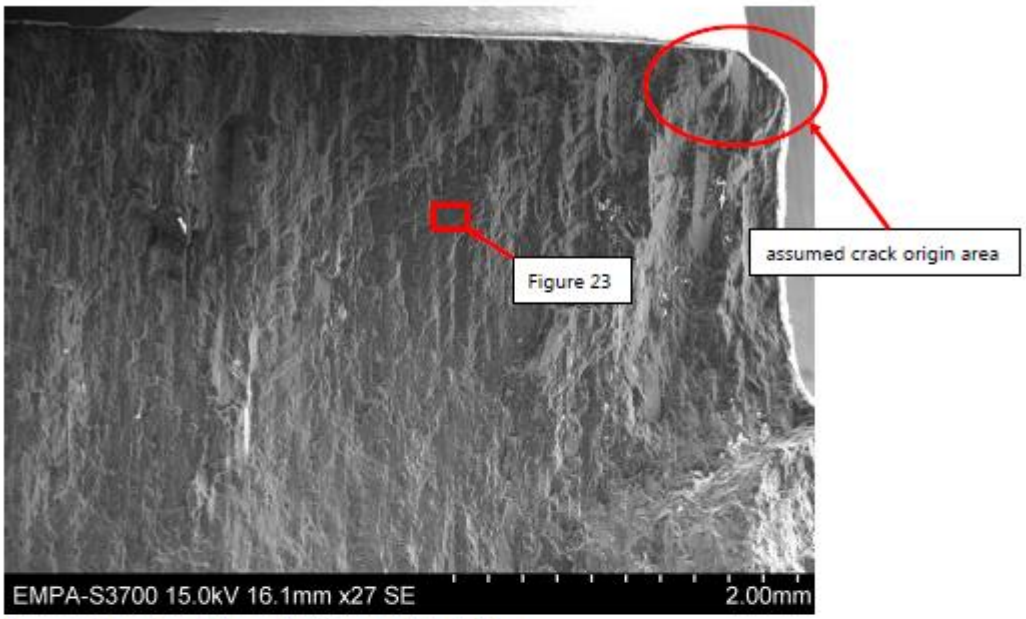

Figure 22: Overview of the crack origin area of the LH fracture

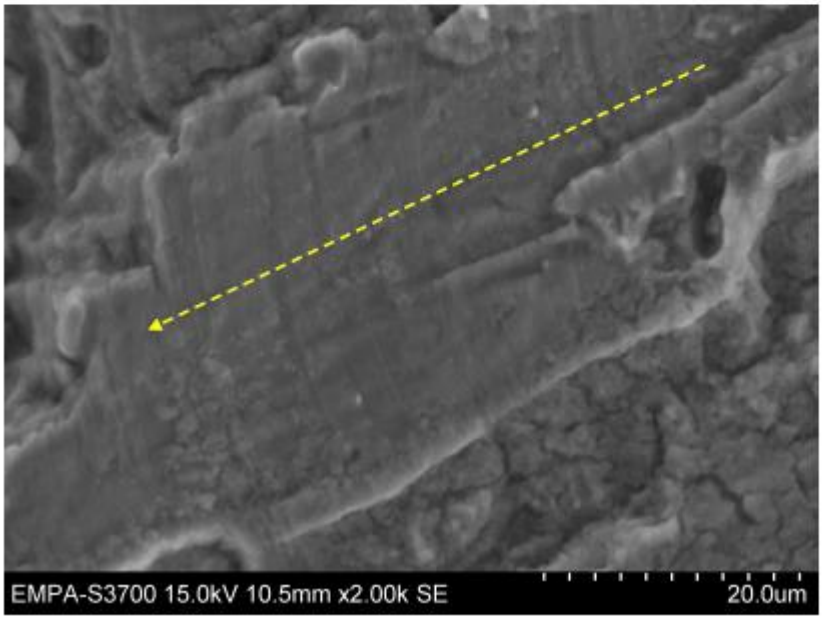

Figure 23: Detailed view of the area indicated in Figure 22 showing fatigue striations

5 Attachment B: FT-IR Analysis

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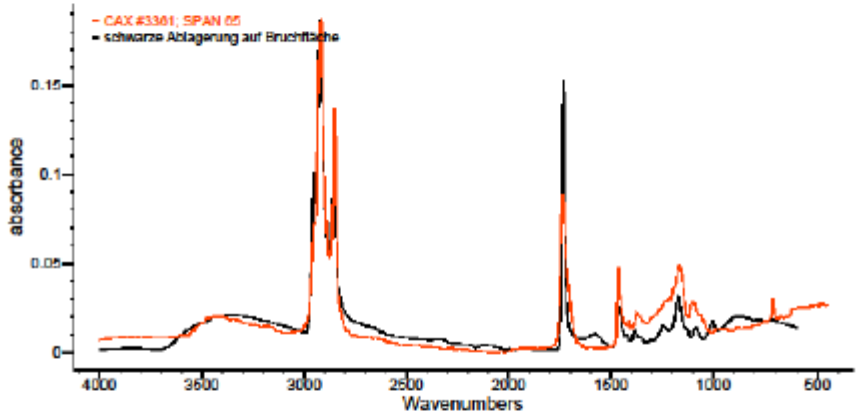
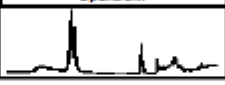
Materials Science and Technology



HQI	Tag	ekt	DB	ennun	Name:	Spektrum	Comments
005.44			CAX	3361	SPAN 65		Chemical Description= SORBITAN TRISTEARATE Description= NON IONIC

1

Este relatório final foi aprovado pela direção do GPIAAF, nos termos do n.º 3 do art.º 26.º, do Decreto-Lei n.º 318/99.	This final report was approved by the management of the Portuguese SIA, as per article 26, no. 3, of Decree-Law no. 318/99.

A equipa de investigação.

The Investigation Team.