1. INVESTIGATION

1.1 History of the Flight

The flight had to be made according flight plan from the Brno-Tuřany aerodrome to Altenburg in Germany. Estimated time of departure was on May 26, 1998 at 0600 UTC, flight level 180.
On the same day at 0602,42 UTC the pilot requested the TWR ATC unit for engine start-up. When it was approved a standard reciprocal communication and procedures followed till 0607,18 when the pilot reported delay at holding point of the runway 28. After approximately 4 minutes she reported readiness for departure. From TWR she received approval to line up, clearance to take-off, information on wind and instruction to change to Brno Radar frequency when airborne. The pilot confirmed all this at 0611,15, lined up runway 28 and accomplished take-off. Take-off run, take-off itself and initial climb flight phases went on normally according to statements of witnesses that observed the departure from aerodrome area. At 0613,05 the pilot reported on the TWR frequency that she needs to land. (She did not change to Brno Radar when airborne) She received instruction to continue a Southern (left-hand) circuit and to report final for runway 28. At this time the first contact was made with the aeroplane by secondary radar at a height of about 520 ft AAL and 560 metres north from runway 28. The pilot did not confirm the instruction, did not turn for the Southern (left-hand) circuit, but continued to turn for the northern (right-hand) one. Since she did not confirm repeated approval for the left-hand circuit and continued the right-hand one, she received information from TWR that it is possible to continue the Northern circuit, clearance to land to runway 28 and was offered assistance after landing. Without any confirmation. At this time the height was approximately 930 ft AAL and position 2,8 km North from the aerodrome. The aeroplane started gradually to descend and to turn as the pilot probably intended to accomplish approach for runway 28. However it did not happen and the aeroplane hit the ground at 0615,28 approximately 600 m North from the runway 28 threshold. The aeroplane was flying very low in the last phase of flight according to statements of witnesses. The last height recorded by the secondary radar was approximately 120 ft AAL 13 seconds prior to the impact onto ground. Witnesses described the attitude of the aeroplane prior to strike to ground as very unusual.

1.2 Injuries to Persons

Injuries	Crew	Passengers	Other Persons
Fatal	1	1	
Serious			
Minor/without injury			

1.3 Damage to Aircraft

The aircraft was completely destroyed when it hit the ground.

1.4 Other Damage

The soil was contamined with fuel and oil from the aircraft.

1.5 Crew Information

Commander 30 years old (woman)
Licence: Private Pilot of Aeroplanes No. 4952-NIOL, valid till July 25, 1999, issued on August 10, 1995 by Bezirksegierung Wesser-Ems, 26106 Oldenburg, Germany
Ratings:

- single reciprocating engine land aeroplanes with the maximum take-off mass of 2000 kg - valid till July 25, 1999
- IFR CAT I - valid till August 21, 1998

Note: The Swiss Federal Office for Civil Aviation validated the German licence with ratings by the Licence No. 38280 issued by Bundesamt fur Zivilluftfahrt Maulbeerstrasse 9, CH-3003 Bern. The Pilatus PC-12 type of aeroplane was entered.
Flight experience: 651 hours 43 minutes in total, 397 hours 12 minutes in total on Pilatus PC-12. It was not possible to establish the exact flight experience, because the last entry into the Pilot's LogBook was made on November 27, 1997. The Aeroplane LogBook was used to find out missing data. The last entry into the Aeroplane LogBook was made on May 14, 1998 though the aeroplane has been provably operated since that time.
On May 25, 1998 the pilot accomplished as a commander of the PC-12, registration marks HB-FOJ aeroplane a flight from Germany to the aerodrome of Brno-Tuřany, where she landed at 18.33.
Note: The pilot used to fly often to the Brno-Tuřany aerodrome, only in May she landed here 8 times at least.

1.6 Aircraft Information

a) Aeroplane

Type Pilatus PC-12/45, registration marks HB-FOJ
Manufacturer Pilatus Flugzeugwerke AG, production number 158, year of production 1996, category Standard, subcategory Normal, for VFR day, VFR night, IFR category I operations. Use: For operations without remuneration.
Certificate of Airworthiness HB-FOJ issued by the Bundesamt fur Zivilluftfahrt on February 3, 1997, valid till revocation.

b) Engine

Pratt&Whitney PT 6A-67B type, production number PCE-PR 0011, has been for more than 409.35 hours in operation. It was not possible to establish operational hours more exactly - see paragraph 1.5.

c) Propeller

Hartzell HC-E4A-3 type, production number HJ-676, has been for more that 409.35 hours in operation. It was not possible to establish operational hours more exactly - see paragraph 1.5.
It was not assessed in details if the system of maintenance has been followed. The Pilatus Aircraft Ltd. company made the last yearly check on Order number 71855/5429 on November 7, 1997. The last 100HR check was made by the same company on Order number 4.2.5532 when the aeroplane has logged 388.55 hours.
During common talks with the Swiss Federal Office for Civil Aviation and with the Pilatus company discrepancies have been found concerning flap actuators mounted onto the right-hand wing. Flap actuator No. 327 has been mounted as the outer one according to manufacturer's records. It has been found after the accident that it is the inner right-hand actuator. Production number 357 of the second actuator at the right-hand side has been found after the accident. This production number is not among the assembly records at the Pilatus company.

d) Used Fuel and Oil

Kind of used oil and its quantity has not been examined
As witnesses stated the aeroplane was filled with 900 litres of fuel on May 25.1998.

e) Mass and Balance in the Critical Flight

The aeroplane was within the mass and balance limitations of the Pilot's Operating Handbook in the critical moment.

1.7 Meteorological Information

Flight forecast for the Czech Republic from May 26, 1998 0400-1300 UTC:
Situation: Shallow lower pressure trough extends from Southern Scandinavia. Secondary cold front proceeds via Germany to East. Surface wind of 190-280°/3-6 mps will intensify temporarily. Clouds - base layer SCT-BKN 900-1200, ST 500-700, TOP 2000-2500, CU, TCU 3-5000, CB 8000.
Actual weather at the Brno aerodrome on May 26, 1998 at 0600 UTC:
LKTB 2606600Z 34001 MPS 5000 BR SCT 073 12/11 Q 1008 NOSIG=

1.8 Aids to Navigation

All radio navigation facilities of the aerodrome were in operation when the aeroplane was departing.

1.9 Communications

Radio communication between the aeroplane and Tower was going on prior to and during take-off.

1.10 Aerodrome Information

The LKTB aerodrome was in operation in the time of departure and provided all necessary services. It had no influence upon development of the accident.

1.11 Flight Recorders

The aeroplane was not fitted with any means of record.

1.12 Place of the Accident

The accident site is located close to a field road passing from the Southern end of the Šlapanice village to the aerodrome of Brno-Tuřany, approximately 600 metres North from the Eastern edge of taxiway A of the Brno-Tuřany aerodrome. Traces of the aeroplane made by the right-hand wing, nose of the fuselage and the left-hand wing were directed to the North. Completely destroyed fuselage with remainders of wings and parted power unit were about 35 m from the beginning of traces at direction deflected by 45° to the left. Bodies of both the dead persons were found very close to the wreckage.

The aeroplane hit the ground in a steep spiral almost vertically with heading of about 90°. Leading part of the right-hand wing tip made the first impact. The right-hand wing was completely destroyed. Immediately afterwards the fuselage hit the ground by its nose that was also completely destroyed. Then the aeroplane turned upside down and to the right over the left-hand wing and on its longitudinal axis and bounced off into air again. The wing was warped in waves along the section depth. The second impact onto to ground was made by the left-hand part of the horizontal tail unit. Rotation on longitudinal axis can be seen very well from its deformation. Remainders of the fuselage impacted in opposite direction taking into consideration the first impact onto ground. Engine and seats were rejected by centrifugal force during this motion in the direction of motion of the wreckage and were found at the right-hand side in front of remainder of the fuselage. The aircraft overshot in rotation on longitudinal axis to the right after impact onto ground and partially obstructed the pilot's body during reverse motion.

A more detailed description of the wreckage has not been made due to further development of investigation. Only descriptions of aircraft parts with causal relation to the accident were selected and are bellow.

Kinematics of the aircraft impact is evident from motion of the battery accumulator inside the aeroplane. After impact the battery, being an object with high specific mass, torn off from its attachment in the rear part of the fuselage and passed almost parallely with the fuselage axis into its pressurised part. During the next phase of motion of the aeroplane the battery damaged freight door at the left-hand side of the fuselage.

Rudder of the aeroplane was found deflected to the left side and blocked in this position due to deformation of its own structure and of structure of the lower tail part of the fuselage. This situation allows to state that the rudder was deflected by this way already prior to the impact onto ground.

Setting that corresponds to reduced thrust, the beta range, was found on both the Power Control Lever and the propeller blade setting governor. The propeller itself has signs of damage that appeared at flight setting range, but character of

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deformation of propeller blades does not show that the propeller was working at flight range driven by high engine power.

Seat belts on both the crew seats were found open and fully functional after the accident. The central lock and the belt sockets do not show damage by stress nor by violent opening due to considerable forces acting in the moment of impact onto ground. An assumption can be made that the crew was not fastened during take-off.

Asymmetrically deflected wing flaps were found in wrecks of the wings. The left-hand wing flap was so deflected that shafts with sleeve box thread were extended to the length of 100 mm from the both outer and inner actuators (this position corresponds with flap extension of 13° according to later information from the manufacturer).

Shafts of both the actuators on the right-hand wing were fully retracted. Flap extension was 0° on the right-hand wing.

The system of the wing flap mechanical control was partly in destroyed wings and partly in the wing centre-section. Left-hand flexible shaft was in the central part of the fuselage. It was torn off at one end from its sleeve of the flap driving unit (PDU) and pulled out from the actuator sleeve at the opposite end. The part of the shaft that transmits torque at the PDU side was missing and it has never been found. A local bending is evident on the shaft approximately in the half of its length, close to the place where it passes through bushing between the pressurised and unpressurised parts of the fuselage. The bending occurred when the aeroplane was being destroyed.

Parts of the aeroplane that were in relation to the cause of the accident in subsequent phases of investigation, i.e. emergency flap control selector (ALTERNATE FLAP) switch that cuts motion of flap controls (FLAP INTERRUPT), and 30A circuit breaker from the flap electrical circuit, were not found.

After the accident firemen cut a hole through skin and structure of the rear part of the fuselage in order to turn off the emergency locator transmitter and to disconnect the battery accumulator.

Any parts showing that they were damaged prior to impact of the aeroplane onto ground were not found.

1.13 Medical Information

Findings of the complex forensic analyse show that the direct cause of death of both the persons, the pilot of the aeroplane and the passenger, were injuries to organs of vital importance. Death of both the persons came immediately when the injuries occurred and it could not be absolutely warded off.

Injuries found, investigation at the accident site and statements of witnesses lead to a conclusion that the pilot was sitting very probably in the left-hand pilot seat and the passenger in the right-hand pilot seat in the moment of the accident. It cannot be definitely established if both the persons had their seat belts fastened. Open belts without any damage to locks that were found at the seats of the aeroplane and location of bodies out from the fuselage show rather that the seat belts were not used.

Neither acute nor long-term pathological changes of essential character that might be put into causal relation with development of the accident have been found by autopsy of both the dead persons and by additional microbiological

analyse. Toxicological analyse excludes intoxication of both the persons by alcohol and by breathing of products of imperfect combustion.
Biochemical analyse of pre-death somatological status of the pilot and passenger shows that both the persons were conscious in the period of critical situation. -Biochemical signs of intensifying stress reaction have not been found within the period of at least 20 seconds prior to death. Commencing activation of energetic metabolism with delivery of saccharides stored in muscles that could occur during stress of muscles due to inflight situation and due to higher short-term mental load has been found for the pilot.
Conclusions of analyses together with other findings can be probably explained so that the pilot and the passenger evaluated the inflight situation as solvable and life not endangering in the incipient stage. The passenger assisted intensively to solve the situation by interventions into the controls in the last phase of flight.

1.14 Fire

No fire occurred on board.

1.15 Search and Rescue

It was not necessary to organise any search. Rescue actions were initiated immediately when the accident occurred.

1.16 Tests and Research

Some parts of the aircraft were passed through the Swiss Accident Investigating Body (BfU) to Switzerland for expert analyses. Their list is in Enclosure 10.

1. Report of the Swiss Federal Laboratories for Materials Testing and Research (EMPA) - Analyse of the flap mechanical system'
   (The entire report is included as Enclosure No. 3)
   a) Conclusion of analyse of the inner left-hand flexible shaft of the flap system:
      Wires forming the shaft were considerably disrupted by corrosion. It led to reduction of strength of the shaft and to its shear in torsion. The so called „black corrosion" - chemical composition Fe_3O_4 - that develops at higher temperatures without free access of air, is in question. The corrosion was caused by moisture condensing in the mechanical system due to pressure changes because one end of the shaft at the PDU side is in the pressurised part and the other end at the Actuator side is in the unpressurised part.
      The last motion, when the shaft failed, was in direction of flap retraction.
      Note: The right-hand inner flexible shaft of the HB-FOJ aircraft was analysed as well and the „black corrosion" in developed stage resulting in reduction of torsion strength of the shaft has been found also here.
   b) Analyse of other parts of mechanical system of flaps:
      No other malfunction in the system has been found.

2. Report of Wissenschaftlicher Dienst Stadtpolizei Zurich - bulb analyse of the warning display (CAWS)
(The entire report is included as Enclosure No. 4)
The „FLAPS" warning lamp was illuminated on the warning display in the moment when the aircraft hit to ground

3. Report of the Pilatus and Bfu companies - record of failures of the Flap Control and Warning Unit (FCWU) and its decoding, see Appendix 5.
Recording capacity of 20 failures was full after 6 flights. Due to the fact that the records have relation only to flap control by the normal control selector (motion of flaps is not recorded in case of use of emergency flap control) and due to incompleteness of aircraft operational records in the Aircraft Log Book, it is not possible to assign information on motion of flaps and possible failure to the critical and previous flight.
The last recorded failure is drop of PDU speed bellow allowed limit. Delay of motion of flaps by more than 1.8 s after relevant command from the flap control system was a frequent failure. It shows to mechanical damage to the flap driving system.

4. Inspection of the flap position indicator made by employees of the Civil Aviation Authority CR (The entire report is available as Appendix No. 11).
Assessment of print of the indicator needle was made by 6x magnifying glass before it has been sent for analyse to Switzerland. Beginning of track of the released indicator pointer has been found approximately at 13° of flap deflection.

5. Analyse of the radar record made by the RADAR, s.r.o. company
(The entire analyse is available as Appendix No. 6)
Based on this analyse and transcription of communication between the involved aircraft and LKTB Tower analyse of progress of all the critical flight has been made including assumed progress since the moment when the aircraft was unsticked till the first radar contact. This analyse is available as Appendix No. 8 and 9.
It shows that the crew had only a very limited time for flap retraction. That is why they did not retract the flaps the most probably by means of the ALT SWITCH step by step, but they used ALT SWITCH permanently for continuous motion of flaps from the take-off up to the retracted position.

1.17 Additional Information

Five eyewitnesses were heard in course of the investigation. Two employees of Air Traffic Services and two persons staying at the aerodrome area in the time of the accident stated in conformity about progress of the flight and confirmed information gained from communication and radar records. The fifth witness, employee of the Czech Airport Administration, has described situation that occurred in evening hours after arrival of the involved aircraft to the aerodrome of Brno-Tuřany on May 25, 1998. When performing her job at a counter she talked to crew of the aircraft after departure of passengers. The pilot's father told her that they have some troubles with flaps. But he refused offered technical assistance and explained that he will repair the trouble with his daughter

themselves. When the aircraft was filled up with fuel they were both working for some time on remedy of the trouble. They left the aerodrome together about 30 minutes after arrival.

Draft of letters between the the HB-FOJ aircraft hirer (HH company), respectively LW company, which was the aircraft owner and Pilatus company as the aircraft manufacturer is available in Appendix No. 7. Mr. H.P. Graf, Swiss accident investigator, handed over these letters to the Civil Aviation Authority CR, at the meeting on results of the EMPA analyse in Zürich.

The letters show that troubles with reliability of the flap system occurred already since production. At the beginning only the flap control unit (FCWU) interrupted motion and the flaps had to be controlled by means of the ALT SWITCH. When it had been used the hirer of the aircraft reset the FCWU by a device delivered by the Pilatus company. The Pilot's Operating Handbook of the PC-12 aeroplane states that it is always necessary to reset the FCWU when ALT SWITCH had been used. But it is not determined who is allowed to carry out this action.

Troubles with the flap system were intensifying because another trouble began to occur according to letters from the HH. Falls out of the 30A circuit breaker that secures the PDU electrical circuit were the troubles. So the flaps were staying in the position, where their motion was interrupted by FCWU intervention. This very frequent trouble could be remedied only by pushing in the circuit breaker again.

Due to the fact that the Pilatus company was not able to remedy the troubles, quarantee for the flap system was extended till November 11, 1998. The aircraft manufacturer together with the manufacturer of the entire mechanical system, Vickers company, had to solve the problem within this period.

2. ANALYSES

- The aeroplane started the most probably to roll to the right after take-off and the pilot decided to make a right-hand circuit and to land back at the aerodrome.

  Occurrence of the right-hand roll may be deduced, in adition to other proves, from the fact that the pilot did not follow instruction of air traffic controller to turn to the left and continued to fly right-hand circuit without any other communication.

- Troubles with reliability of the flap system occurred on the HB-FOJ aircraft already since production. At first only by interruption of flap motion by the control unit (FCWU) so that flaps had to be controlled by means of the ALT SWITCH. Troubles with the flap system were intensifying during further operation. When flaps were being deployed from one position to another one, ciruit breaker of the flap electrical circuit started to fall out and the flaps used to stay blocked in an intermediate position. The manufacturer did not fully remedy the malfunction although it was a subject of complaint for many times. Crew of the aircraft (meant the pilot of the aeroplane and her farther) were resetting the flap control unit (FCWU) themselves always when the ALTERNATE FLAPS SWITCH had been used. Later, when the 30A circuit breaker started to fall out, they pushed it back themselves as well. The manufacturer of the aeroplane

was aware that both these two actions are being accomplished - see Appendix No. 7.

- The aeroplane was operated the most frequently on unpaved runway with length of 650 m at Hodenhagen (Germany). The crew was often forced to land on this runway with flaps not fully extended.
- Frequent troubles with flaps could lead to a certain decrease of awarness of the crew and to a feeling of easy way to solve an extraordinary situation. This assumtion is confirmed by results of the autopsy (Appendix 13). According to analyses the pilot developed an increased physical and psychical load, but without any apparent stress.
- Analyse of assumpted flight progress since the moment when the aircraft was unsticked till the first radar contact shows that the crew had only a very limited time for retraction of flaps. The crew probably used the normal way of retraction for the first time. Asymetry occurred during retraction and motion of flaps was stopped due to FCWU intervention. Inconsistently with the Pilot's Operating Handbook the crew probably continued to retract flaps by means of ALT SWITCH. In addition this way of retraction was not used step by step, but the ALT SWITCH was used permanently for continuous flap retraction. Another procedure is less probable and in fact impossible to accomplish due to short time period and short path flown in the above mentioned phase of flight.
- It is not possible to exclude at all the possibility that the crew used the ALT SWITCH step by step after intervention of FCWU, but the pilot did not react to gradually developing asymetry of control in time.
- It can be excluded that the asymetry occurred already prior to take-off because the banking moment of flaps unambigously becomes evident much more intensively at lower airspeed. However the take-off run, lift up and intial climb were observed without any troubles. We cannot assume as well that the crew accomplished take-off with the FLAPS warning already illuminated.
- Analysis of parts of the aircraft that have been foud and other analyses do not provide exact answer to the question, why the crew did not extand the flaps back in order to eliminate banking moment to the right-hand wing. The two following possibilities may be accepted as explanation:

  a) Pilot's father retracted continuously flaps by means of the ALT SWITCH, while the pilot herself was controlling the aeroplane. She was not able to evaluate exactly the suddenly occurred asymetry and to retract the flaps back to take-off position by means of the ALT SWITCH.

  b) The possibility that the circuit breaker of the electrical circuit fell out just in the moment when the right-hand flap was retracted seems to be less probable. This fact would make the possibility to extand flaps again impossible.
- It is necessary to point out the fact that the left-hand flexible shaft was sheared in torsion during flap retraction. The fracture area does have tracks showing that the part of the shaft connected to actuator was exposed to abrasion due to the other part rotating towards flap extension.
- An assumtion can be made that the aircraft entered a steep right-hand spiral as a result of significant banking moment to the right due to asymetric deflection of flaps when airspeed was reduced. The airspeed was the most probably reduced as the crew tried to decelerate the aircraft in order to extand landing gear and to land. According to statements of witnesses the aircraft lifted up its nose prior to the dive. In addition the pilot probably used reduced propeller

thrust beta range to decrease airspeed The passenger probably tried to prevent from entry into steep turn (maybe fall over wing) by intervention into controls Printed traces of pedal pattern have been found on the sole of his left shoe He also held manual controls of the aircraft in his hands according to results of autopsy

- The radar record graphic analyse shows that the aeroplane attained the highest airspeed of approx 150 kts on the Northern leg of its flight path (i.e. approximately when it was downwind). Airspeed dropped to approximately 110 kts in the last phase of the flight at 6:14:54 to 6:15:17.

3. CONCLUSIONS

- The pilot had required qualification for the flight and a valid III. Class Medical Certificate
- Weather had no impact upon development of the accident
- The aerodrome of departure was serviceable and had no impact upon development of the accident
- Airworthiness of the aircraft was afected by a hidden malfunction.
- When the main flap control system has failed the pilot used an alternative procedure inconsistently with the Pilot's Operating Handbook for retraction of wing flaps Diference of 13° between the left-hand and the right-hand flap was a result of uncorrectly applied alternative procedure for retraction of flaps

CAUSE OF THE ACCIDENT

- The critical situation was caused by flap asymetry It occurred as a result of shear in torsion of the left-hand inner flexible shaft

- Loss of controllability caused by reduction of airspeed with use of Beta range in the final phase of the flight was the direct cause of the accident

- Uncorrect application of Emergency Procedures for flap retraction listed in the Pilot's Operating Handbook was the main cause of the accident

4. SAFETY RECOMMENDATIONS

The Civil Aviation Authority of the Czech Republic reserves decision upon measures to be taken for the manufacturer and for the Swiss Federal Office for Civil Aviation due to the fact that the PC-12 aeroplane does not have any Type Certificate in the Czech Republic and is not operated either by a Czech operator

Prague September 30 1998

Ing Boleslav Stavovčík
Director of the
Civil Aviation Authority of the Czech Republic