



Investigation report

C 3/2006 L

Incident involving an airliner landing at Helsinki-Vantaa airport on 20 February 2006

Translation of the Finnish original report

OH-LEE

EMBRAER 170

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SUMMARY

Incident involving an airliner landing at Helsinki-Vantaa airport on 20.2.2006.

An incident occurred at Helsinki-Vantaa airport in Finland at 11:36 on 20 February 2006. At this time, two of the four main landing gear tyres burst as the aircraft flying the scheduled Finnair Oyj flight from Warsaw to Helsinki landed. Accident Investigation Board Finland (AIB) decided to appoint an investigation commission, C 3/2006 L, for this incident. Air Accident Investigator Markus Bergman was named investigator-in-charge accompanied by investigator Tapani Vääntinen as member of the commission.

As the aircraft was approaching Helsinki, the pilots inadvertently applied the emergency/parking brake lever instead of the speed brake lever. Even after the lever was released, one of the two parking brake circuits in the aircraft malfunctioned and retained pressure. The result of this was that the outermost tyres on the main landing gear burst during the landing roll. Apart from the damaged tyres, the incident did not result in damage to the aircraft or injuries to people.

The investigation revealed shortcomings in the aircraft's emergency/parking brake system, the indication and warning system as well as with airline regulations and pilot action.

The direct causal factor of the incident was a malfunction in the emergency/parking brake system. Contributing factors include the pilots' error as they applied the speed brakes, the fact that the aircraft's indication and warning system did not provide clear enough information to the pilots about the malfunction and the fact that the pilots forgot that the emergency/parking brake telltale lamp was on. The emergency/parking brake system had functioned abnormally twice before but this had been reported in the aircraft's technical log book by using a technical remark rather than a malfunction report, which was also a contributing factor to the incident as a remark did not require the technical personnel to initiate immediate fault isolation activities.

The investigation commission issued three recommendations. A recommendation was given to the aircraft manufacturer for them to redesign the emergency/parking brake system so that it be impossible for the emergency/parking brake to retain pressure when the brake lever is disengaged in the air and/or to publish a procedure according to which pilots are able to depressurise the emergency/parking brake system aloft without compromising flight safety. A second recommendation for the aircraft manufacturer was that they also redesign the emergency/parking brake warning and indication system so as to provide sufficiently detailed information to pilots of system status and possible faults when airborne. The third recommendation was given to the airline. It was for them to issue unambiguous instructions on how to report aircraft malfunctions and how to enter technical remarks.



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ABBREVIATIONS

UTC	Co-ordinated Universal Time
KT	Knot(s)
FMS	Flight Management System
ASR	Air Safety Report
COORS	Confidential Observation and Occurrence Reporting System, i.e. an Air Traffic Service safety report
RMK	Remark
OM-A	Operations Manual Part A
OM-B	Operations Manual Part B
EICAS	Engine Indication and Crew Alerting System
ATC	Air Traffic Control
CIS	Crew Information System
TWR	Air Traffic Control Tower
JAR	Joint Aviation Requirements
GND	Air Traffic Control Ground
VHF	Very High Frequency
ILS	Instrument Landing System
CAT I	Category 1
DVDR	Digital Voice Data Recorder
FDR	Flight Data Recorder
CVR	Cockpit Voice Recorder
CMC	Central Maintenance Computer
MFD	Multifunction Display
EMER, EMERG	Emergency
PRKG	Parking
BRK	Brake



SYNOPSIS

An incident occurred on the scheduled Finnair flight FIN742X from Warsaw to Helsinki at 11:36 on 20 February 2006. As the aircraft was approaching Helsinki-Vantaa airport the pilots inadvertently applied the emergency/parking brake lever instead of the speed brake lever. Even after the parking brake lever was released, one of the two parking brake circuits in the aircraft malfunctioned and retained pressure. As the aircraft landed on runway 22L at Helsinki-Vantaa airport the outermost tyres on the main landing gear burst. All times in the report are Coordinated Universal Time (UTC).

The aircraft, registration OH-LEE, was an E-170 type 76-seat turbojet airliner, manufactured by Empresa Brasileira de Aeronautica S.A. RBS Aerospace Limited owned the aircraft and Finnair Oyj operated it.

There were 29 passengers onboard as well as five crew. The incident did not result in any injuries to persons or damage to the aircraft, apart from the burst tyres.

Accident Investigation Board Finland (AIB) was notified of the incident on 20.2.2006 and subsequently decided to appoint an investigation commission, C 3/2006 L, for this incident. Air Accident Investigator Markus Bergman was named investigator-in-charge accompanied by investigator Tapani Vääntinen as member of the commission. The Brazilian accident investigation authority Centro de Investigação e Prevenção de Acidentes Aeronáuticos (CENIPA) were notified of the incident. They designated Lt Col. Fernando Silva Alves de Camargo as their accredited representative assisted by adviser Mr. Nuno Aghdassi, representing the manufacturer of the aircraft.

On 7.9.2006 the original draft of the final report of the investigation was dispatched to the Finnish Civil Aviation Authority and Finnair Oyj as well as to others concerned for comment. On 26.9.2006 the English translation of the final report draft was dispatched to CENIPA and Embraer for comment. AIB received the statements and comments by 30.11.2006.

The investigation was completed on 11.12.2006.



1 FACTUAL INFORMATION

1.1 History of the flight

1.1.1 Events during the flight

The scheduled Finnair flight FIN742X departed Warsaw, Poland (EPWA) at 10:10 on 20.2.2006 for Helsinki-Vantaa airport (EFHK), Finland. The aircraft was an Embraer E-170 airliner, registration OH-LEE. There were 29 passengers and five crew onboard.

As per Air Traffic Control (ATC) instructions, the aircraft was approaching Helsinki-Vantaa runway 15. During the approach, the ATC asked whether the pilots would rather prefer to land on runway 22L. The answer was affirmative, because by doing so they could reduce the remaining flying time and the taxiing distance to their expected stand.

Due to the landing runway having been changed the aircraft was slightly above the normal approach profile. The captain, who was the Pilot Flying (PF), decided to apply the speed brake in order to reduce altitude. However, instead of selecting the speed brake lever he inadvertently pulled the emergency/parking brake lever. Even as he was doing so, he noticed his error, mentioned this to the co-pilot and disengaged the lever. Thereafter, the captain pulled the speed brake lever all the way back.

After having released the lever, the captain noticed that the white emergency/parking brake telltale lamp was still on and mentioned this to the co-pilot. They pondered the situation and, to the best of their memory, the captain tried to turn the lamp off by re-engaging and disengaging the emergency/parking brake lever (this could not be verified from the recorded data). However, the lamp remained on.

Both pilots had to concentrate on radio traffic as well as on ATC instructions while the captain was simultaneously entering new data into the Flight Management System (FMS) since the landing runway had been changed. As per their account, they forgot that the white emergency/parking brake telltale lamp was on.

The aircraft landed on runway 22L at 11:36. After landing both pilots noticed that the aircraft decelerated abnormally rapidly. Apart from this, they did not notice anything unusual during the landing roll. After the landing roll they could not make it to the taxiway, even by increasing engine power. Instead, they came to a halt while still partially on the runway.

After the aircraft had stopped on the runway the control tower (TWR) asked them whether they could continue taxiing and if they were experiencing technical problems. The captain responded that their brakes were stuck and, estimated that they could continue taxiing momentarily.

The TWR instructed the next aircraft approaching the runway to initiate a missed approach procedure. Almost immediately after this, the ATC decided to start using runway 15 for landing. They also had runway 22L inspected for any possible signs of hydraulic leaks or other deposits.

As per the captain's account, they managed to get the aircraft rolling again by repeatedly operating the emergency/parking brake lever and the brake pedals. The pilots felt that the aircraft controlled normally and they told the ATC that they would like to continue taxiing to the stand. The ground controller (GND) asked whether it was possible that they had deposited hydraulic fluid on the runway. The captain answered that it was not, adding, as his impression, that they had brake problems.

They continued to taxi by following the "Follow Me" vehicle to stand 902. While taxiing, the pilots reported the problem to the airline's technical services.

All passengers deplaned normally at the gate followed by the cabin crew who left on a crew transportation vehicle. At this stage, the pilots did not inform the passengers or cabin crew members of the malfunction.

When the aircraft was inspected at the stand, it became clear that two main landing gear tyres had burst during landing. The pilots filed the mandatory Air Safety Report (ASR) of what had happened.

Airport maintenance reported to the GND that they had found pieces of rubber during the runway inspection. Since the pilots of flight FIN742X could no longer be contacted by radio, the GND requested the Follow Me vehicle driver to relay this information to the crew or to the technical services' representatives at the aircraft. The driver then told the controller that two of the aircraft's tyres were damaged. The GND filed a Confidential Observation and Occurrence Reporting System (COORS) report. Runway 22L was eventually cleaned and ready for operations at 12:30.



Figure 1. Right main landing gear tyres after the incident (Photo: Finnair Oyj)

The pilots did not report the malfunction to the ATC, their own airline or to their cabin crew during the flight.

The cabin crew were informed of the incident only after Accident Investigation Board had decided to proceed with an investigation. Soon after this the captain contacted the cabin crew.

1.1.2 Events before and after the incident

Pilots who had flown the incident aircraft had twice before reported problems with the emergency/parking brake. A report was filed on 22.1.2006 pointing out the tendency of the emergency/parking brake to jam during stopovers. Furthermore, on 9.2.2006 pilots filed a report on having received an "EMER BRK FAULT" warning on the ground after they had released the emergency/parking brake lever. This warning indicates an anomaly in the emergency/parking brake system hydraulic pressure. In both cases the pilots filed the occurrence as a remark (RMK) in the technical log book rather than as a malfunction report.

Finnair Oyj's Operations Manual Part A (OM-A) instructed pilots how to enter data into the technical log book. A remark (RMK) should be used, for example, to report pilot actions performed resulting from the aircraft's electronic fault detector system reports as well as to report correct aircraft system functions, such as "autoland". Remarks were not to be used to report malfunctions.

After the incident all four main landing gear tyres were changed, emergency/parking brake system settings were checked and the emergency/parking brake valve was changed. The maintenance was performed by following the type maintenance manual as well as the manufacturer's recommendations. Once maintenance was completed the aircraft returned to service.

Pilots flying the same aircraft on 2.3.2006 filed another report on the emergency/parking brake system's abnormal functioning. After having disengaged the emergency/parking brake lever on the ground they received an "EMER BRK FAULT" warning and the brakes stayed on. After reapplying the lever, the brakes released and the warning disappeared. The emergency/parking brake system was tested according to the Fault Isolation Manual (FIM) and the following maintenance was ordered: Another changing of the emergency/parking brake valve, changing the emergency/parking brake system's hydraulic fluid leak fuses (2) as well as taking a sample of and analysing the hydraulic fluid. Later it became known that impurities were discovered in the hydraulic fluid. However, before the aforementioned maintenance tasks were completed the aircraft returned to service and pilots were given the following written instructions on the Crew Information System (CIS) regarding possible anomalies in the emergency/parking brake system: *"On the ground the LEE often generates an "EMER BRK FAIL" warning on EICAS. In this case pull the parking brake lever to the "up" position whereafter vigorously push it down. It should take no more than two attempts to turn the parking brake light off. If this is not the case, contact NCC technical services."*

1.2 Injuries to persons

There were no injuries. There were 29 passengers and five crew members onboard.

1.3 Damage to aircraft

The outermost tyres on the left and right main landing gear burst.

1.4 Other damage

No other damage.



1.5 Personnel information

The flight was an enroute training flight and the captain was the instructor pilot. Prior to becoming an E-170 captain, he had flown as captain on ATR-72 aircraft. The co-pilot of the flight had successfully passed his type rating check flight for E-170s on 28.12.2005. He received the type rating on 13.1.2006. The E-170 was the first aircraft type which he was flying for Finnair.

Captain Age 36
 Licence: JAR Air Transport Pilot's Licence, valid until 12.4.2010
 Medical certificate: JAR class 1, valid until 25.3.2007
 Ratings: All required ratings were valid.

Flying experience	Last 24 hours	Last 30 days	Last 90 days	Total experience
All types	9 h 3 min	80 h 33 min	206 h 49 min	7621 h 49 min
Type concerned	9 h 3 min	80 h 33 min	206 h 49 min	268 h 42 min

Co-pilot Age 27
 Licence: JAR Commercial Pilot's Licence, valid until 13.1.2011
 Medical certificate: JAR class 1, valid until 23.3.2007
 Ratings: All required ratings were valid.

Flying experience	Last 24 hours	Last 30 days	Last 90 days	Total experience
All types	5 h 3 min	33 h 27 min	33 h 27 min	277h 8 min
Type concerned	5 h 3 min	33 h 27 min	33 h 27 min	33 h 27 min

1.6 Aircraft information

The aircraft was a 76-seat turbojet airliner. The aircraft was configured with two main landing gear and one nose gear, two tyres on each.

Registration:	OH-LEE
Owner and operator:	Owner RBS Aerospace Limited, operator Finnair Oyj.
Manufacturer:	Empresa Brasileira de Aeronautica S.A.
Type:	ERJ 170-100LR
Year of manufacture:	2005
Engines:	Two General Electric CF34-8E turbofans.
Certificate of registration:	Issued on 27.9.2005
Certificate of airworthiness:	The certificate issued on 27.9.2005 was valid.
Weight and balance:	The weight and centre of gravity were in the permissible range.

1.7 Meteorological information

The weather did not affect the occurrence.

1.8 Aids to navigation and radars

Aids to navigation and radars had no effect on the occurrence.

1.9 Communications

Radiotelephony communications operated normally. After the aircraft came to a halt, still partially on the runway, relevant communications were conducted on the TWR VHF frequencies. The investigation commission had access to all of the recorded radio traffic during approach, landing and taxi.

1.10 Aerodrome information

The incident occurred at Helsinki-Vantaa international airport (601902N, 0245748E) in Finland. The pilots flew an ILS CAT I approach and the aircraft landed on runway 22L (22 left) which is 3440 metres long and 60 metres wide.

1.11 Flight recorders

Finnair Oyj's Technical Services decompressed the data contained on the Digital Voice Data Recorder/Flight Data Recorder (DVDR/FDR) and the Central Maintenance Computer (CMC). This data provided a clear picture of what transpired during the incident. Data printouts are in numerical form. Immediately after the incident it was assessed that



the Digital Voice Data Recorder/Cockpit Voice Recorder (DVDR/CVR) data were not relevant to the investigation and, therefore, were not analysed.

1.12 Wreckage and impact information

Not relevant to the investigation.

1.13 Medical and toxicological information

No medical and toxicological tests were performed.

1.14 Fire

There was no fire.

1.15 Rescue operations and survival aspects

The pilots did not mention the technical malfunction to the ATC, their own airline or to their cabin crew during the flight. During the flight no preparations were made for the possible consequences of the malfunction. The ATC received preliminary information on the brake problems after the aircraft had landed. Rescue services were not informed of the incident.

1.16 Test and research

At the request of the aircraft manufacturer, the emergency/parking brake dual valve on the incident flight was sent to the United States for analysis. Hydro-Aire (the manufacturer of the valve) conducted the tests, witnessed by representatives of Embraer and Liebherr (the supplier of the valve). The analysis did not uncover anything that could explain the problem on the aircraft. The valve that had been installed on the aircraft after the incident was removed on 2.3.2006 and sent for analysis when yet another emergency/parking brake malfunction occurred. This time Liebherr conducted the tests in Germany with a representative of Finnair Oyj participating. Minor deviations from normal values were discovered. However, the analysis is still ongoing using, among other things, low temperature tests.

Aircraft hydraulic fluid samples were taken after the emergency/parking brake system malfunctioned on 2.3.2006. Impurities were found in the samples. However, no conclusive proof of their effect on system performance could be established. Hydraulic fluid samples were retaken on 10.4.2006. No impurities were found in these samples.

1.17 Organizations and management

Finnair Oyj's flight training syllabus for the E-170 type is comprehensive and certified by the aviation authority. The syllabus does not include any information or exercise for a situation in which the emergency/parking brake stays on in the air.

Finnair Oyj's Operations Manual Part A, valid at the time of the incident, provides instructions on how to fill in the aircraft's technical log book. The Manual states that a remark (RMK) should be used, for example, to report pilot actions performed resulting from the aircraft's electronic fault detector system reports as well as to report correct aircraft system functions, such as "autoland". Remarks were not to be used to report a malfunction.

As per Finnair Oyj instructions, the certified technical personnel had to acknowledge all of the pilots' RMKs in the technical log book by entering the word *Noticed* into the actions field and by relaying said information onward.

1.18 Additional information

A fully mechanical emergency/parking brake system has been installed on the E-170 aircraft to act as the secondary brake system in emergencies as well as for parking the aircraft. The system is operated via the emergency/parking brake control lever on the cockpit pedestal, which mechanically adjusts brake pressure through a dual valve. In normal conditions the emergency/parking brake receives its hydraulic pressure from aircraft hydraulic systems 1 and 2. In addition, there are two pressure accumulators, separated from the main hydraulic lines with check valves. Should normal hydraulic pressure be unavailable, the accumulators provide sufficient pressure for six full brake applications. The emergency/parking brake system is a standalone system independent of the main brake system and does not require any electrical power. System operation is the same on the ground as aloft. The E-170's main brake system includes various protective mechanisms which, among other things, prevent brakes-on landings (touch down protection). However, the use of the emergency/parking brake overrides these mechanisms.

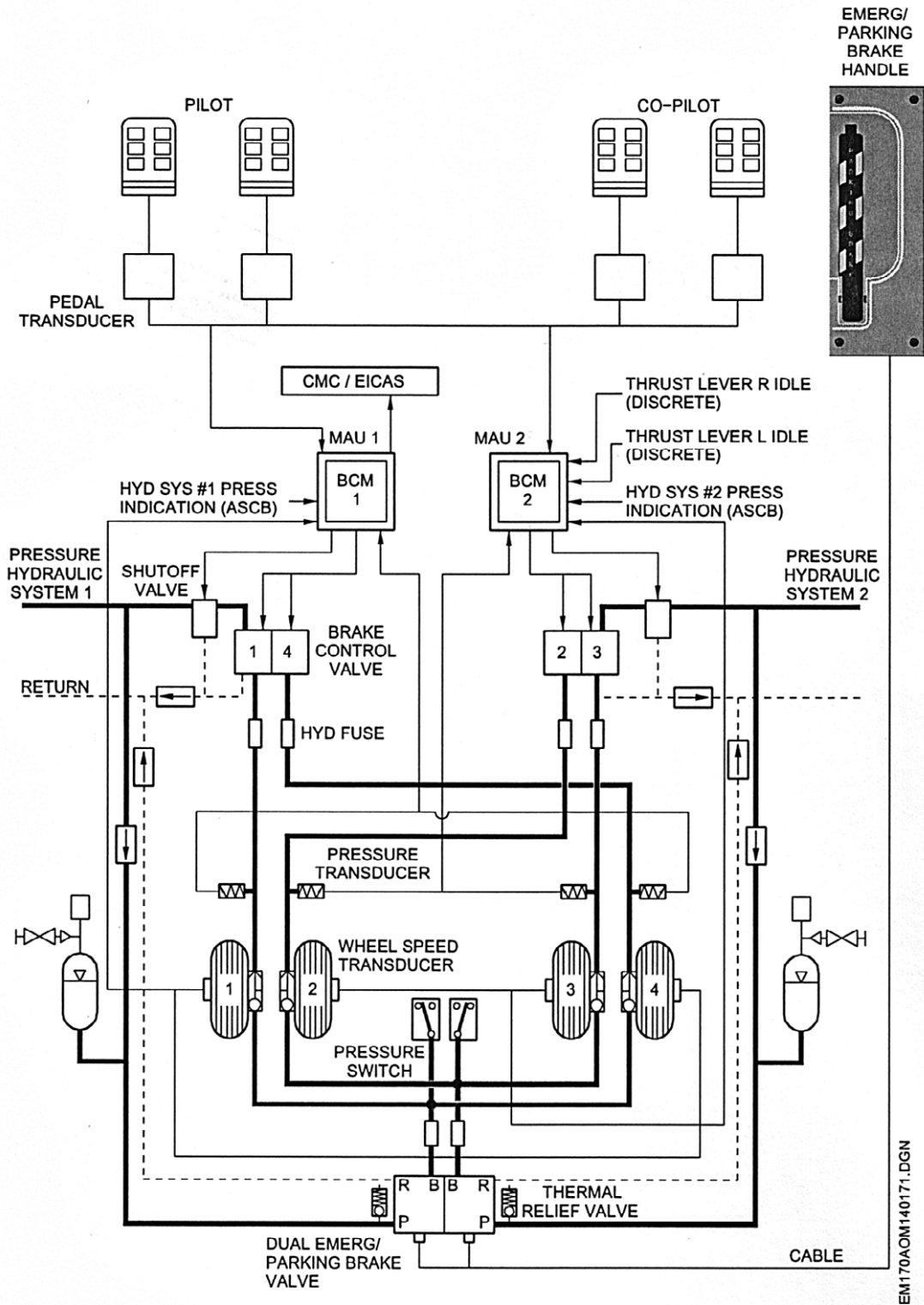
Two pressure sensors measure hydraulic pressure on the emergency/parking brake system. If at least one detects sufficient pressure, a small white text "ON" on the rectangular EMER/PRKG BRAKE telltale lamp comes on on the cockpit instrument panel.

The E-170 is designed so that when the aircraft is airborne and all systems are operating normally, no telltale lamps or warnings are on on the cockpit instrument panels.

Messages related to the emergency/parking brake system are shown to the pilots on the Engine Indication and Crew Alerting System (EICAS). Emergency/parking brake system warnings, notifications and messages are shown on the EICAS only in some phases of the flight and during other phases they are blocked. For instance, the message EMER BRK FAULT, indicating a pressure differential between the two brake circuits, is blocked when takeoff roll speed reaches 80 KT until after 30 seconds have elapsed from landing or when wheel spinup falls below 30 KT. Numerical and other information regarding the emergency/parking brake system is shown to the pilots on the Multifunction Display (MFD) on the relevant page's schematic diagrams. Emergency/parking brake system pressure downstream the dual valve can not be shown on the MFD. Only the cockpit instrument panel's telltale lamp "ON" indicates that the emergency/parking brake system is on.



The aircraft manufacturer's statistics, consisting of information gathered from 135 E-170/190 aircraft, lists 321 technical reports related to the emergency/parking brake system. Of these, 24 cases involve instances when pressure remained in the emergency/parking brake system even after the brake lever was released. All of these 24 cases occurred on the ground. Furthermore, in 31 cases the emergency/parking brake valve was defective. One documented incident exists when all main landing gear tyres burst during landing. According to the manufacturer in this particular instance, the emergency/parking brake lever was not disengaged at landing.



BRAKE SYSTEM SCHEMATIC

Figure 2. The emergency/parking brake system schematic (Diagram: Finnair Oyj E-170 OM-B)



2 ANALYSIS

2.1 The incident flight

The flight from Warsaw to Helsinki-Vantaa airport was in its approach phase. Since the landing runway had been changed, the aircraft was slightly above the normal approach profile. The captain who was the Pilot Flying (PF) decided to apply the speed brake in order to reduce altitude. However, instead of pulling the speed brake lever he inadvertently pulled the emergency/parking brake lever. As per his account, he noticed his error as soon as he was manipulating the lever. After having released the lever he noticed the emergency/parking brake white telltale lamp was still on.

The emergency/parking brake system operates independently of the main brake system and system operation is the same on the ground as aloft. Therefore, hydraulic pressure flows into the emergency/parking brake system every time the control lever is engaged. Once the lever is disengaged the system should then depressurise. The emergency/parking brake is not needed in the air. However, the lever is not blocked when airborne and its use is not specifically prohibited.

The aircraft manufacturer's statistics show the number of technical reports related to E-170/190 emergency/parking brake system. The investigation commission regards the number of malfunctions where pressure remains in the system even after brake lever release as significant. Taking this into consideration, combined with the fact that the use of the brake lever is not blocked in the air, the possibility for recurring incidents resembling this one is remarkable.

The captain of the aircraft explained that the speed brake lever on the MD-80 aircraft, which he had flown in the past, was located in the same place on the pedestal as the emergency/parking brake lever is on the E-170. It is the opinion of the investigation commission that the probable cause for using the wrong lever was the captain's relatively short practical experience in flying the E-170, compounded by a momentary workload increase due to the change of landing runway. His previous experiences on the MD-80 and ATR-72 aircraft could also have carried over and contributed to the use of the wrong lever.

As per pilots reports they noticed that the white telltale lamp was on and they discussed the situation for a moment. However, they soon had to focus their attention on the ATC instructions as well as on entering new data into the Flight Management System as the landing runway had been changed. As per their account, both pilots then forgot that the emergency/parking brake lamp was still on. The next time they remembered the light was only after having landed.

According to the opinion of the investigation commission, the main reason why the pilots forgot about the white telltale lamp was that when airborne, cockpit crews receive no warning, remark or message when the emergency/parking brake is on or if the system malfunctions. The only indication of system pressurisation is the system status light.

Said light is white and quite small. On the ground the light indicates that the parking brake is on. If the emergency brake is used, the light indicates that brake pressure is available. According to the E-170 Operations Manual Part B (OM-B), white lights are used to report normal operation or normal system status to the cockpit. However, on buttons a white striped bar is used to indicate that the button is not in its normal position.

When airborne, the emergency/parking brake telltale lamp should not normally remain on. Pilots, however, do not have published instructions or procedures for cases when the emergency/parking brake telltale lamp is on in the air even if the lever is disengaged. If the emergency/parking brake telltale lamp is on in the air, there is no way for the pilots to find out whether hydraulic pressure remains in one or both of the emergency/parking brake circuits.

Should the emergency/parking brake be on during landing, a serious incident or mishap may result as abnormal deceleration or burst tyres make the aircraft more difficult to control. The investigation commission deems that a white telltale lamp indicating normal system operation is inadequate to attract the pilots' attention during a flight to the fact that the emergency/parking brake is on or possibly malfunctioning.

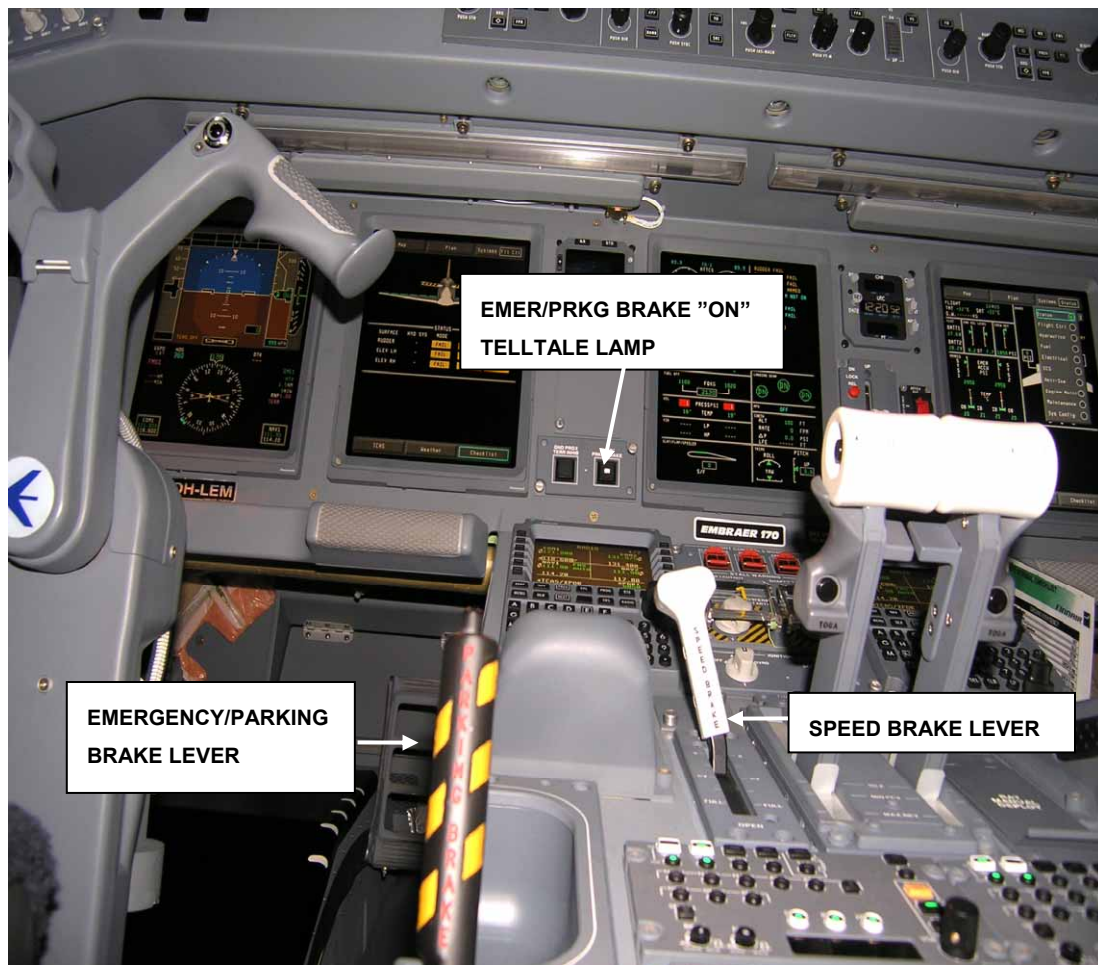


Figure 3. The emergency/parking brake lever, the telltale lamp and the speed brake lever (Photo: Finnair Oyj)



The flight during which the incident occurred was an enroute training flight for the co-pilot, included in the E-170 type rating syllabus. The co-pilot had flown only 33 hours and 27 minutes for Finnair as well as on the E-170. The captain, who was the instructor pilot, had amassed over 7600 total flying hours, 268 h 42 min of which on the E-170. Both pilots were trained to recognize the meaning of the emergency/parking brake white telltale lamp. However, since no other warnings were in effect they did not consider this important enough to warrant a more detailed evaluation in lieu of proceeding with the approach. Considering the circumstances and the remaining fuel onboard they could have tried to identify the cause of the telltale lamp in more detail. The investigation commission considers it likely that both pilots' short experience in flying the E-170 partly contributed to the fact that they forgot about the emergency/parking brake telltale lamp.

According to studies, pilots' unintentional or deliberate procedural oversight has contributed to several aviation mishaps. From 1980 to 1996, 279 fatal approach-and-landing accidents occurred. In 121 (43.4%) of these, procedural omission or inappropriate action contributed to the accident. (Source: Flight Safety Foundation Approach-and-Landing Accident Reduction, ALAR, Task Force).

2.2 Post-landing events

After landing, despite an obvious brake system malfunction, once the captain managed to get the aircraft rolling again he decided to continue taxiing to the stand. It is the opinion of the investigation commission that they should not have continued to taxi because they did not know what the malfunction entailed. Nor did they have any information on its consequences or possible damage to the aircraft during landing.

Because both pilots had forgotten about the emergency/parking brake telltale lamp, they failed to report the malfunction or the possible safety risk to the ATC, cabin crew or the airline while still airborne. The malfunction could have made the aircraft more difficult to control at landing. Therefore, for safety reasons it would have been important to raise airport rescue readiness as well as to prepare the cabin for landing.

The cabin crew remained unaware of the incident until the airline contacted them after the Accident Investigation Board had launched the investigation. At this time the captain himself informed all crew members of the incident and recounted the events on the flight. The investigation commission believes that the pilots should have informed the cabin crew of the incident as soon as possible after landing.

2.3 Shortcomings observed during the investigation

The investigation revealed that there are shortcomings in the E-170 emergency/parking brake system as well as in its indication and warning system. During the time of the investigation the aircraft manufacturer has acted responsibly regarding the observed shortcomings and has begun improving the system. According to information received from the manufacturer, the E-170 emergency/parking brake system's indication and warning system redesign is expected to be complete in 2006. According to the manufacturer some of the Aircraft Maintenance Manual procedures have been reviewed in order to increase the reliability of the emergency/parking brake system.

The investigation revealed that Finnair Oyj's instructions for pilots, valid at the time of the incident, regarding the difference between reporting malfunctions and entering remarks (RMK) into the technical log book were not sufficiently clear. It is important to log remarks in order to gather information on the aircraft's technical condition. However, the incorrect use of a RMK may hold up fault isolation and repair activities, compromising flight safety. Instructions on how and when to use RMKs should be made as unambiguous as possible. During the investigation Finnair Oyj responded to the shortcomings regarding the instructions on how to report malfunctions and enter remarks by making the instructions more explicit.



3 CONCLUSIONS

3.1 Findings

1. The pilots had the required licences and qualifications.
2. The aircraft was registered and its airworthiness certificate was valid.
3. The airline had introduced the aircraft type to its fleet five months before the incident flight.
4. The flight was an enroute training flight for the co-pilot. Neither pilot had much experience flying the aircraft type in question (possible contributing factor).
5. Abnormal operation of the emergency/parking brake system on the incident aircraft had been reported twice before. However, pilots had reported the occurrences as RMKs rather than technical malfunctions (contributing factor).
6. The landing runway was changed in the final phase of the flight.
7. The captain, PF, inadvertently used the emergency/parking brake lever instead of the speed brake lever (contributing factor).
8. Even though the brake lever was released, the white emergency/parking brake tell-tale lamp stayed on.
9. The pilots noticed that the emergency/parking brake light remained on but subsequently forgot about it (contributing factor).
10. When the aircraft is airborne, the cockpit warning system does not provide sufficiently detailed information to pilots of the fact that the emergency/parking brake is on or possibly malfunctioning (contributing factor).
11. The flight training syllabus for E-170 aircraft did not include any information or exercise for a situation in which the emergency/parking brake stays on in the air.
12. During the landing roll, the aircraft decelerated abnormally rapidly and the aircraft came to a halt at the intersection of the runway and taxiway.
13. The outermost tyres on the main landing gear burst during landing.
14. The pilots filed the required Air Safety Report to the authorities.
15. Immediately after the incident the airline and the aircraft manufacturer launched their own investigations of the emergency/parking brake system.

16. After the incident the brake system and its settings were inspected, all main landing gear tyres were changed and the emergency/parking brake valve was changed whereafter the aircraft returned to service.
17. Within about one week of this incident the emergency/parking brake on the very same aircraft remained on after the brake lever was disengaged on the ground. Thereafter the emergency/parking brake valve was changed again as were the fluid leak fuses. Samples of the hydraulic fluid were also taken.
18. No clear fault could be found on the emergency/parking brake system, which could have caused the incident.
19. Statistics compiled from 135 E-170/190 aircraft in service indicate that in 24 instances the emergency/parking brake has retained pressure even though the brake lever was released.
20. This incident falls under ESARR 2 Severity Classification Scheme B; Major Incident.

3.2 Probable cause

The direct causal factor in the incident was a malfunction of the emergency/parking brake system, allowing one of the two brake circuits to retain pressure even after the brake lever was released. The investigation could not determine a clear cause for the malfunctioning of the emergency/parking brake system.

The contributing factors are included in paragraph 3.1 "Findings".



4 RECOMMENDATIONS

1. The investigation revealed that it is possible for the emergency/parking brake system to retain pressure both aloft and on the ground even after the brake lever is disengaged.

The investigation commission recommends that the aircraft manufacturer redesign the emergency/parking brake system so that it be impossible for the emergency/parking brake to retain pressure when airborne and when the brake lever is disengaged and/or to publish a procedure according to which pilots can depressurise the emergency/parking brake system aloft without compromising flight safety.

2. The investigation revealed that when airborne, pilots do not receive any warning, caution or message regarding the fact that the emergency/parking brake system has remained on or is malfunctioning. Instead, the only available information in the air is a small white light indicating system status. During the time of the investigation the aircraft manufacturer had begun to design an improvement to the emergency/parking brake indication and warning system.

The investigation commission recommends that the aircraft manufacturer redesign the emergency/parking brake warning and indication system so as to provide sufficiently detailed information to pilots of system status and possible faults when airborne.

3. The investigation revealed that inappropriately entered remarks (RMK) into the technical log book may result in not isolating and rectifying genuine technical faults. During the time of the investigation the airline issued more explicit instructions to pilots on how to enter remarks and to report technical malfunctions.

The investigation commission recommends that the airline issue unambiguous instructions on how to report aircraft malfunctions and how to enter technical remarks.

Helsinki, 11.12.2006

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REFERENCES

The following material is stored at the Accident Investigation Board Finland:

1. The AIB decision on proceeding with an investigation
2. Incident reports
3. Excerpts of the pilots' licences
4. Transcripts of crew interviews
5. Embraer 170/190 type rating syllabus
6. Recorded documents involving the occurrence flight
7. Copies of Air Traffic Control logs
8. Aircraft registration and airworthiness information
9. Excerpts from the Aircraft Operations Manual
10. Transcripts of recorded radio traffic
11. Flight Data Recorder and Central Maintenance Computer data printouts
12. Meteorological information at the time of the occurrence
13. Excerpts from the Airline Operations Manual
14. Photos
15. Test and research reports
16. The investigation commission's journal and correspondence.