REPORT

HCLJ510-2012-96	**Serious incident**		
Aircraft:	SAAB 2000	Registration:	SE-LOM
Engines:	2 - Allison AE 2100A	Flight:	Scheduled, IFR
Crew:	3 - no injuries	Passengers:	47 – no injuries
Place:	Copenhagen Airport, Kastrup (EKCH)	Date og time:	20.3.2012 at 06:10 UTC

All times in this report is UTC.

The Aviation Unit of the Danish Accident Investigation Board (AIB) was notified of the serious incident by the Area Control Centre at Copenhagen Airport, Kastrup on 20.3.2012 at 0635 hrs.

The International Civil Aviation Organization (ICAO), the European Aviation safety Agency (EASA) and Statens Havarikommission SHK Sweden was notified on 22.3.2012.

Factual information

History of the flight

During final approach to runway 22L at 200 feet height AGL, the yellow L ELEVATOR degrade caution illuminated on the Engine Indicating and Crew Alerting system (EICAS) display.

The commander (PF) continued the approach as there was no problem controlling the aircraft.

A moment later, just before the flare (about 30 ft AGL), the aircraft rapidly started to pitch nose up. At the same time a red L ELEVATOR INOP warning illuminated on the EICAS display.

At that point the PF felt, that a safe landing was not possible and the PF initiated a go-around.

After a MAYDAY call was transmitted and an initial radar vectors for a missed approach was received from ATC, the first officer (PNF) performed the relevant malfunction checklist for a hydraulic leak and the LH elevator inoperative.

The PF had some difficulties trimming the aircraft pitch during the go-around, but after a while the PF gained control with the aircraft.

The flight crew requested a new approach to RWY 22 L and radar victors for a 10 nm final. As a precaution the flight crew briefed the passengers and the cabin crew to prepare an emergency landing.

The landing was uneventful and the fire and rescue services were on standby at the scene.

The serious incident took place in daylight and under visual meteorological condition (VMC).

Damage to aircraft

There was no damage on the aircraft.

Personnel information

The commander was a holder of a valid ATPL (Airline Transport Pilot License). The Type rating SAAB 2000 was issued on 20-10-2011 and valid. The medical certificate was valid with no limitations and the last medical examination was done on 21-02-2011.

Flying experience until the day of the serious incident

	Last 24 hours	Last 90 Days	Total
All types:	5:40	240	8620
This type	5:40	240	1120
Landings (this Type)	3	138	-

Aircraft information

The SAAB 2000 was a two engine high performance turboprop aircraft with a capacity of up to 58 passengers and two pilots and one or two cabin crew.

Maximum takeoff mass:	50,265 lb.	
Empty mass:	30,424 lb.	
Payload:	13,010 lb.	
Power plant:	2 x Allison turboprop	3,096 kW (4152 shp) each
Propeller:	2 x 6 blades constant speed Dowty propellers	
Cruising speed:	367 kts.	
Service ceiling:	31000ft	
Aircraft total time:	25105.3	
Aircraft cycles:	24703	

SAAB 2000 elevator system

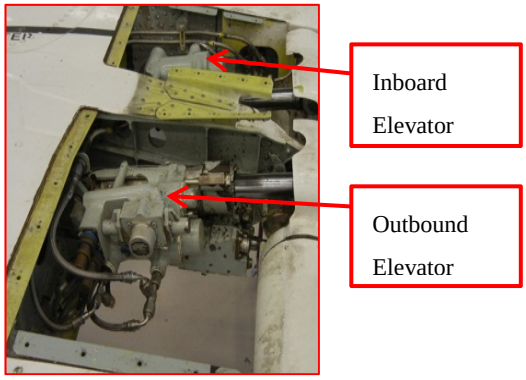
Ref: Aircraft Operations Manual (AOM)

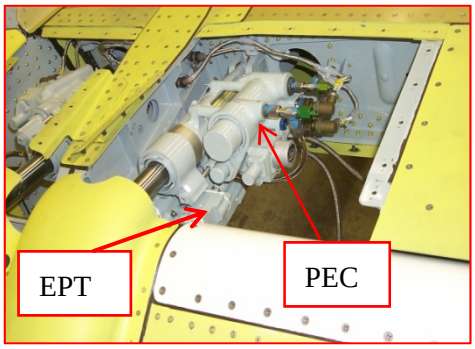
Elevator control is a fly-by-wire system with hydraulic servos. Pitch trim is performed by changing elevator neutral position. Left and right control columns are mechanically interconnected. Left and right sides are independent. To create forces in the elevator system a break-out stick force unit is installed. The break-out function gives a slight resist force when moving the control column out of trimmed position. Trimmed position is always the same control column position (neutral position).

A control column command is sensed by the Dual Linear Variable Differential Transformers (LVDTs) which in turn send analog signals to the Powered Elevator Control Units (PECUs) which via control logic and the two mode valves control the dual elevator servos. For redundancy each PECU consists of two servo actuator channels (SAC).

At power-up the elevator system goes through a Pre-Flight Built Test (PBIT) to verify proper function. Part of the test is an end-to-end deflection of the elevators to confirm correct travel. Left and right PBIT is totally independent and elevator deflection may not be synchronic during test. The control columns do not move during PBIT. The first part of a PBIT is a test of the internal logic which

typically results in the elevator test being completed when the end-to-end travel part of the elevator PBIT starts.
If the elevator controls system from the PECU senses a failure from both elevator servo actuators in the same side, or invalid electrical signals from both actuators to the PECUs, the elevator inop caution letters on the EICAS will illuminate. The failed elevator actuators will by damped mode from the PECU, disconnect command signals, the surface will be held close to the failed position by the PECU signals activating a closing of the EPTS (Emergency Trim system) actuator by-pass valve. In case of a single elevator actuator failure or LVDT failure the elevator will act on one actuator and the ELEVATOR Down grade will illuminate on the EICAS.





Technical investigation
Following the serious incident a PBIT was carried out on the elevator system, but the L ELEVATOR INOP remained illuminated on the EICAS display.

The two PECUs were interchanged for trouble shooting, but the L ELEVATOR INOP remained on.

The LH inboard elevator servo was replaced thereafter a new PBIT was performed, with no change in failure status.

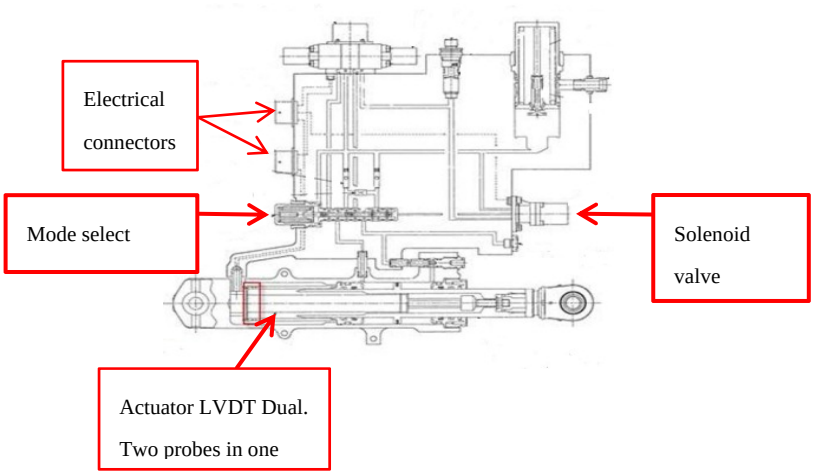
The LH outboard elevator servo was replaced and after a PBIT the LH ELEVATOR INOP warning disappeared. The aircraft was released with no further discrepancies on the LH elevator system.

Both elevator servo actuators were shipped to an approval overhaul facility in the United States by the AIB. The examination of the two servo actuators was monitored by an Accredited Representative from The National Transportation Safety Board (NTSB).

Maintenance history
Four days and 8 flights before the serious incident, the aircraft was released from a scheduled heavy maintenance check. During the check the LH outboard elevator servo was replaced due to a hydraulic leakage. The new installed elevator servo actuator P/N 7U7852-1 SN 0219 was overhauled and returned to the costumer on January 25th 2012.
At the same scheduled maintenance check, a mandatory Service Bulletin SAAB 2000-92-005/006 (inspection and repair/replacement of cable harness in zones 323,332 and 342) was performed.

Generally it was an inspection of the elevator flight control electrical harness for corrosion, between the tail section to the LH and RH elevator servo actuators. During the inspection general corrosion around electrical plugs was discovered. The maintenance shop decided to replace the entire harness involving the Service Bulletin.

Elevator servo actuator



Inboard elevator servo P/N 7U7852-1, Serial no. 0188

Visual external inspection of the unit revealed no obvious damage. All hydraulic ports and electrical ports, with the exception of the hydraulic return port were observed sealed with caps.

After the examination, acceptance tests were accomplished in accordance with the component maintenance manual, revision 8, dated October 30, 2011. The unit passed all tests.

No mechanical malfunction or anomalies were noted which would preclude normal operation.

Outboard elevator servo P/N 7U7852-1, Serial no. 0219

Visual external inspection of the unit revealed no obvious damage. All hydraulic ports and electrical ports were sealed with caps.

The acceptance test was performed in accordance with the Component Maintenance Manual, revision 8, dated October 30, 2011.

The unit passed the Insulation Resistance test.

The Servo valve Linear Variable Differential Transformer (LVDT) test was performed, and the unit passed Channel A test. LVDT Channel B failed later in the test due to an open electrical circuit.

The unit passed the Mode Select valve Operation test.
The solenoid Valve Operation test, which required that the piston ceased movement when the solenoid input fell to between 1 and 5 vdc, was performed. In this instance, piston movement stopped at 10.39

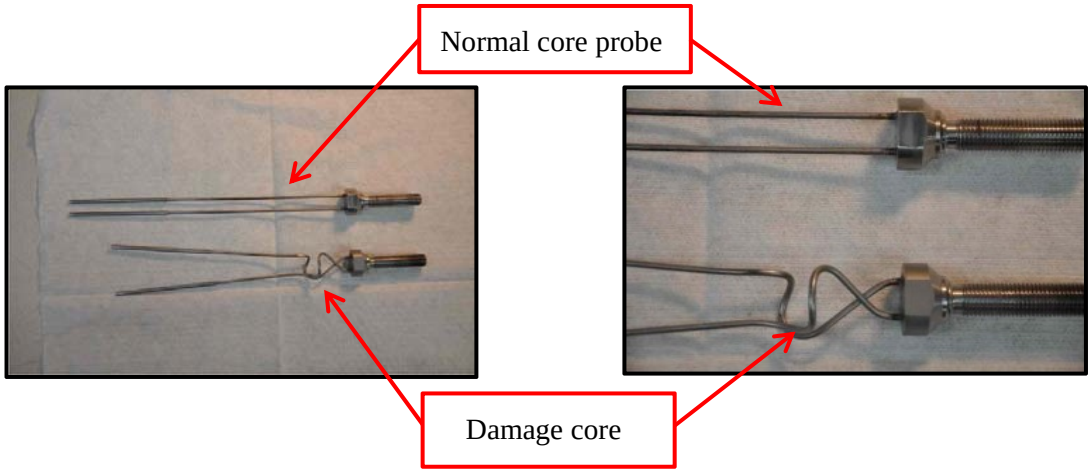
vdc. The investigation group concluded that this failure did not affect the functionality of the unit, and was not related to the symptoms observed in this serious incident.

A series of resistance measurements of all internal transformer coils was performed. All coils displayed comparable resistance when compared to their matching channel counterparts, except for channel B actuator LVDT coil, which exhibited an open circuit between the coil and center tap pins 14, 15 and 16. The unit was subsequently cooled to a temperature of minus 40 degrees Fahrenheit, and the transformer coils were again tested with similar results.

The unit was subsequently partially disassembled in order to gain access to the LVDT assembly. The piston rod end was removed, revealing the LVDT cavity the two cylindrical ferromagnetic core probes. Both probes exhibited curling damage at their bases. The LVDT cavity and both probes were clean, and free of contaminants.

Examination of the LVDT case revealed that both probe coil sleeves had become displaced about 3 mm longitudinally, and broken out of their potting compound.

The maintenance shop had only experienced one case earlier where probes had curled. This failure was announced in the EICAS as L ELEVATOR DEGRADE.



Meteorological information
EKCH 200550Z 24018KT 8000 –RA FEW012 BKN040 05/03 Q1024 NOSIG

Communications
Recorded communication between the aircraft and ATC was of good quality and has been used in the investigation

Aerodrome information

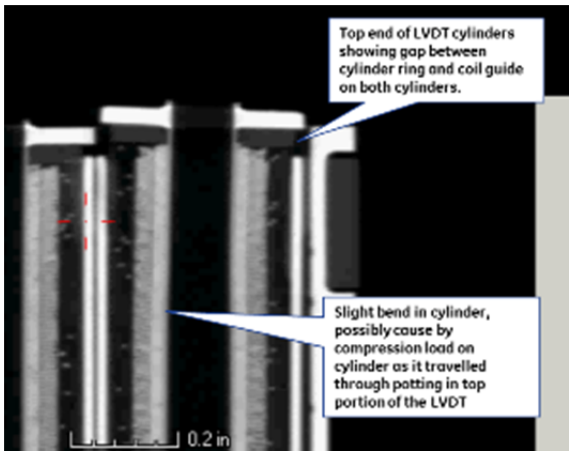
Name:	Copenhagen Airport, Kastrup
Location indicator:	EKCH
Position:	4.4 NM southeast of Copenhagen (55 37 04,50N / 012 39 21.50E)
Traffic permitted:	IFR/VFR
Firefighting / rescue:	Approved to category 9 (ICAO Annex 14) and rescue boats.
Runway 22L:	Asphalt, dimensions 3.300 x 45 m, elevation 8 ft. Slope less than 0,2%
Lighting runway 22L:	PAPI, ALS, THR, TDZ 22L, Centre line, Edge, End.
Navigation aids:	VOR, ILS, and DME.

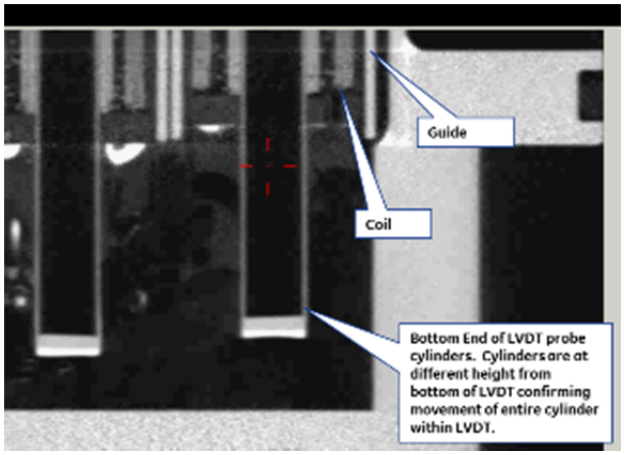
The Copenhagen Airport was equipped with video cameras situated different places in the airport for security monitoring. The recordings were of good quality and used in the investigation

Flight recorders
On the day of the serious incident the FDR was removed from the aircraft. The data from the FDR was of good quality and was used in the investigation.
REF. Appendix 1 Page 8.

Tests and research
The failed LVDT cavity was sent to General Electric (GE) - Advanced Manufacturing Technology Lean Labs for a resolution digital imaging.
During the Lean Labs resolution digital imaging test, there was no identification of the root cause for the damage to the LVDT probes. However there were a couple of areas identified for additional evaluation during destructive inspection:

- Potential damage to the bottom of one of the LVDT
- Void potting at the bottom of the LVDT
- Slight bend in one of the probes cylinders





ANALYSIS

The maintenance shop investigation of the two elevator servo actuators showed no failure to the inboard actuator.

The investigation of the outboard actuator revealed a failure in one coil (channel B) of the two coils in the LVDT. This coil failure resulted in invalid positioning output to the SAC monitoring and illuminated the L ELEVATOR DEGRADE warning on EICAS.

Furthermore, the LVDT probes were found bended in the LVDT cavity where the coils were placed. The bending of a probe would not necessarily degrade the elevator function.

The dual coil LVDT was connected to servo loop closures in the PECU SAC's. Illumination of an L ELEVATOR DEGRAD caution on the EICAS from an elevator servo actuator could be a coil failure in a LVDT.

The electrical harness to the elevator system was replaced 8 flights before the serious incident. A loose connection to the inboard elevator actuator and the confirmed LVDT coil failure on the outboard elevator could lead to an L ELEVEVATOR INOP condition.

A performance history of only one deficiency report on probe curling in a servo elevator actuator indicates that the actuator has a very good dependable record.

When the LH elevator failed, the PF experienced a rapid aircraft and the pilot had difficulties of controlling the aircraft. The PF felt that is was no longer safe to make a landing and initiated a go-around.

The elevator failure occurred in a critical flight phase, just a moment before the flare. A change in the pitch handling was evident and it took a few seconds for the PF to regain fully control of the aircraft.

CONCLUSIONS

It has not been possible to fully determine the actual cause to the LH elevator failure.

It is the opinion of the Danish AIB that the most probable cause leading to the LH elevator inoperative was a combination of:

A failure to one LVDT coil Channel B on the LH outboard elevator

- An intermittent loose connection in one of the new installed electrical plugs to the inboard servo actuator.

Appendix 1