Statens haverikommission
Swedish Accident Investigation Authority

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# *Final report RL 2012:19e*

## Serious incident involving the aircraft SE-DRS in the airspace between Estonia and Finland on 7 December 2010

Ref no L-170/10

2012-10-18



The report is also available on our web site: www.havkom.se

This document is a translation of the original Swedish report. In case of discrepancies between this translation and the Swedish original text, the Swedish text shall prevail in the interpretation of the report.

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Statens haverikommission
Swedish Accident Investigation Authority

The Swedish Transport Agency

601 73 NORRKÖPING

**Report RL 2012:19e**

The Swedish Accident Investigation Authority (Statens haverikommission, SHK) has investigated a serious incident that occurred on December 7, 2010, in the airspace between Estonia and Finland, involving an aircraft with the registration SE-DRS.

SHK hereby submits under the Regulation (EU) No 996/2010 on the investigation and prevention of accidents and incidents in civil aviation, a report on the investigation.

On behalf of the SHK investigation team,

Mikael Karanikas Stefan Christensen

## General points of departure and limitations

The Swedish Accident Investigation Authority (Statens haverikommission – SHK) is a state authority with the task of investigating accidents and incidents with the aim of improving safety. SHK accident investigations are intended so far as possible to determine both the sequence of events and the cause of the events, along with the damage and effects in general. An investigation shall provide the basis for decisions which are aimed at preventing similar events from happening again, or to limit the effects of such an event. At the same time the investigation provides a basis for an assessment of the operations performed by the public emergency services in connection with the event and, if there is a need for them, improvements to the emergency services.

SHK accident investigations try to come to conclusions in respect of three questions: *What happened? Why did it happen? How can a similar event be avoided in future?*

SHK does not have any inspection remit, nor is it any part of its task to apportion blame or liability concerning damages. This means that issues concerning liability are neither investigated nor described in association with its investigations. Issues concerning blame, responsibility and damages are dealt with by the judicial system or, for example, by insurance companies.

The task of SHK also does not include, aside from that part of the investigation that concerns the rescue operation, an investigation into how people transported to hospital have been treated there. Nor does it include public actions in the form of social care or crisis management after the event.

The investigation of aviation incidents is regulated in the main by the Regulation (EU) No 996/2010 on the investigation and prevention of accidents and incidents in civil aviation. The investigation is carried out in accordance with the Chicago Convention Annex 13.

## The investigation

The Swedish Accident Investigation Authority (SHK) was notified on 9 December 2010 that a serious incident involving an aircraft with the registration SE-DRS had occurred in Finland on 7 December 2010. Because the aircraft was registered in Sweden and was flown by a Swedish crew, it was agreed with the Finnish accident investigation authority that the investigation responsibility would be delegated to Sweden and SHK. The decision on the investigation was made on 10 December 2010.

The incident has been investigated by SHK represented by Mr Göran Rosvall, Chairperson until 25 January 2012, Mr Mikael Karanikas thereafter, Mr Stefan Christensen, Investigator in Charge, Mr Lars Alvestål, Operations Investigator and Mr Kristoffer Danèl, Technical Investigator (aviation).

The investigation was followed by Mr Lars Kristiansson, Swedish Transport Agency.

A meeting was held on 01 February 2012 with a number of invited parties with an interest in the incident. At the meeting, SHK presented the facts which existed at the time.

# Report RL 2010:19e

L-170/10
Report completed on 18 october 2012

| | |
|---|---|
| Aircraft; registration and type | SE-DRS, Raytheon Beechjet 400A |
| Class, Airworthiness | Normal, Certificate of Airworthiness and valid Airworthiness Review Certificate (ARC) |
| Owner/Operator | A.J. Produkter Hyltebruk |
| Time of occurrence | 07-12-2010, 08.20 hrs in daylight<br>Note: All times are given in Swedish standard time, (UTC + 1 hr) |
| Place | In the airspace between Estonia and Finland |
| Type of flight | Private |
| Weather | According to METAR Tampere: Variable light wind, visibility above 10 km, cloud 1-2/8 at 2100 ft, 5-7/8 at 2800 ft and overcast at 3500 ft, temp/dewpoint -06/-07 °C, QNH 998 hPa. |
| Persons on board: | |
| crew members | 2 |
| passengers | 2 |
| Injuries to persons | None |
| Damage to aircraft | None |
| Other damage | None |
| Commander: | |
| Age, licence | 59 years, ATPL |
| Total flying hours | 23211 hours, of which 3740 hours on type |
| Flying hours previous 90 days | 13.7 hours, all on type |
| Number of landings previous 90 days | 16 |
| Co-pilot | |
| Age, licence | 26 years, CPL |
| Total flying hours | 1140 hours, of which 240 hours on type |
| Flying hours previous 90 days | 47 hours, all on type |
| Number of landings previous 90 days | 38 |
| Cabin crew members | 0 |

## Summary

When taxiing out for take off for a flight from Tallinn in Estonia to Kokkola-Pietarsaari in Finland with an aircraft of type Beechjet 400A, discrepancies were noted in the compass system. The commander shut down the engines and restarted the systems. When the problems reappeared to a greater degree after take off, the commander decided to turn off the master switch to all avionics and then restart the system.

After the restart, some parts of the system returned, but the attitude information disappeared from the main instruments. The information and database in the computer that is the main instrument in the navigation system also disappeared. The remainder of the flight had to be carried out on standby instruments and by means of radar guidance from air traffic control.

Based on the aircraft's status and the prevailing weather, the commander decided to land in Tampere where a radar-guided approach was possible. The approach and landing was executed without further problems.

Upon fault isolation, it was found that all systems functioned when the batteries in the navigation system's computer were replaced. The manufacturer of

these systems had sent out bulletins about the installation of an additional battery in the relevant units, but this modification was not mandatory and had not been performed by the operator. Disturbances in the navigation system before takeoff were probably caused by distortions in the magnetic field due to the presence of metal in the ground at the airport. The cause of the disturbances in the compass system that reappeared after take off could not be fully determined.

The incident was caused by that the measures that were recommended to solve the known deficiencies in the power supply to the navigation computer system neither were mandatory nor had been performed.

## Recommendations

None.

# 1. FACTUAL INFORMATION

## 1.1 History of the flight

### *1.1.1 Circumstances*

The flight was a private flight with a Beechjet 400A, which is a jet-propelled twin-engined aircraft with seating for 6 passengers, see Figure 1. It was intended to fly from Tallinn in Estonia to Kokkola-Pietarsaari in Finland, meaning a distance of about 270 Nm, see Figure 2. After starting the engines in Tallinn, the navigation system indicated normal values. While taxiing out to the holding point at the runway, a heading warning (HDG[1]) was announced from the system on the aircraft's computer screens, see Figure 3.

The warning indicated that the two sensors that detect the horizontal components of the earth's magnetic field were generating different signals. The two compass indications reportedly showed a difference of up to 180°. The discrepancy compared with the standby compass was up to 90°. These problems may arise where there are disturbances in the ambient magnetic field of the earth, such as those due to iron objects in the ground under the compass. In the present case, the commander suspected that the problems were due to the magnetic compasses being disturbed by re-inforcement bars in the concrete surface of the taxiway.


Figure 1. Beechjet 400A. Photo: Harri Koskinen.

[1] HDG. Heading.


Figure 2. Map of the area.

Figure 3. Heading warning.

### 1.1.2 The flight

The crew taxied to the holding point at the runway, but during taxiing, a warning regarding the AHRS[2] was announced on the PFD[3]. To remove the warnings and undertake a complete restart of the systems, the commander chose to shut down the engines and start them up again. After this, there were no remaining fault indications, and as stated in the interviews, the crew now believed that the problems were solved.

Normal take off from runway 26 was executed, after which the aircraft initially climbed to 2200 feet in a right turn to heading 350° and then continued the climb to the planned flight altitude FL 280. The flight took place mainly in IMC[4] and in icing conditions.

After about 5 minutes flight, parts of the navigation information disappeared and the heading warning was displayed again. The information reappeared, however, and the commander decided that they would continue the flight. However, the information disappeared again, and after it disappeared for the third time, they requested radar vectoring towards Helsinki Airport. The crew performed a fastslave[5] and flew on heading 350° towards a specified point outside Helsinki. Air traffic control informed them, however, that the heading they were holding was 30-40 degrees incorrect. This was shortly followed by a MAG[6] warning and Flight Director[7] warning, upon which the attitude information disappeared. In addition, the standby compass did not display a reliable heading because the front windscreen heating was on, which affects the standby compass.

The commander reported that he was not able to navigate or follow any predetermined heading. He requested assistance from air traffic control in order to fly to the nearest airport, which was Helsinki. In this situation, the crew flew on the standby instruments, see Figures 4 and 5. The systems were then restarted by switching off the “Avionics Master[8]” and then switching it on again. After restarting the system, parts of the altitude and speed information reappeared. The attitude information on the main instruments was gone, for which reason the remainder of the flight had to be carried out on standby instruments. It was also not possible to enter navigation data into the system since the entire database in the FMS was disabled in connection with the restart.

### 1.1.3 The landing

At the same time, the crew received information on the weather at Helsinki Airport. The air traffic controller stated the weather at 08.20 hours to be: Light wind, visibility 3000 metres, 1-2/8 100 ft, 5-7/8 200 ft and current weather deterioration. The commander then decided to go either to Turku (in Swedish, Åbo) or Tampere-Pirkkala (in Swedish, Tammerfors), where the weather was better. Turku, however, had no radar guidance. The commander responded that they did not have complete operational flight data (frequencies, etc.) for landing at Tampere-Pirkkala. The air

[2] AHRS, Attitude and Heading Reference System. System that displays attitude and heading information.
[3] PFD, Primary Flight Display. Screen that displays the main flight instruments.
[4] IMC, Instrumental Meteorological Conditions. Weather conditions that require that the flight takes place by means of instruments.
[5] Fastslave. Quick reset of the AHRS system.
[6] MAG warning. The system has detected that the magnetic heading information is invalid.
[7] Flight Director. Aid to navigation that overlays the attitude information. It provides the pilot with assistance to steer both vertically and laterally.
[8] Avionics Master. Master switch for avionics and radio equipment.

traffic controller then called Tampere-Pirkkala and received the necessary information that could then be forwarded to the crew via radio.

The weather in Pirkkala was at that time: Light wind, visibility above 10 km, clouds 1-2/8 at 2100 ft, 5-7/8 at 2800 ft and overcast at 3500 ft. The commander then decided to go to Tampere-Pirkkala for landing. Since the problems on board had severely limited the capacity of the navigation equipment, it was not possible to execute an ILS approach[9].

However, there was local radar at Tampere-Pirkkala Airport that made a PAR[10] approach possible. The crew therefore requested permission to land in Tampere and planned for a PAR approach. Approach and radar guidance were accomplished by means of the standby instruments, and the aircraft landed at Tampere-Pirkkala Airport without further problems.


Figure 4. Standby instruments.

[9] ILS, Instrument Landing System. Landing method where radio signals are received from the ground and presented to the pilot so that an approach can be made down to the landing runway.

[10] PAR, Precision Approach Radar. Aids to approach that were originally only used for military purposes. The air traffic controller has access to a precision radar that provides information on the aircraft's position, vertically and laterally, and can then give instructions to the crew on how they should steer in order to come down below clouds and land visually.

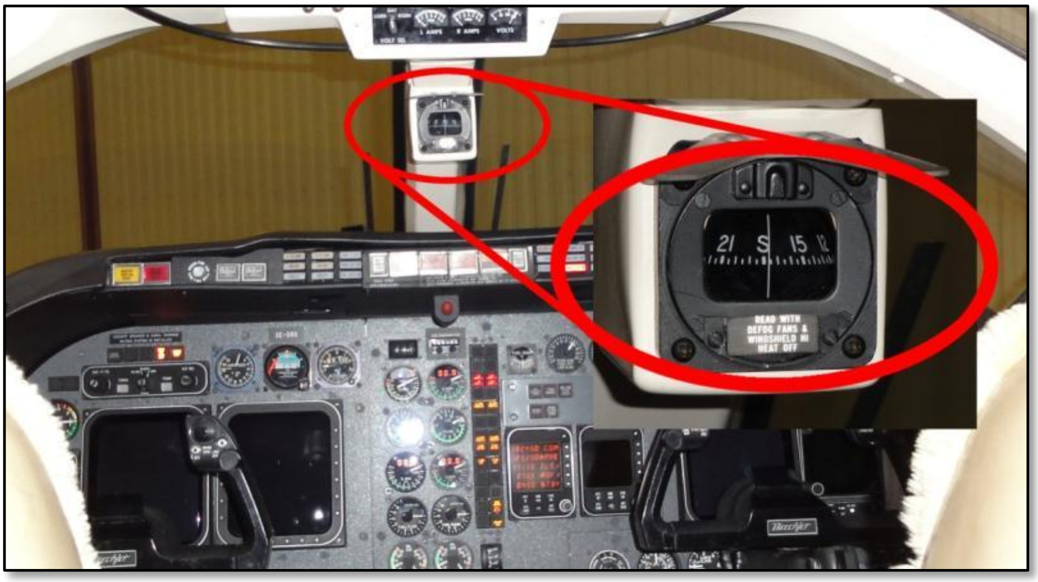


Figure 5. Standby compass.

## 1.2 Injuries to persons

| | Crew members | Passengers | Total | Others |
|---|---|---|---|---|
| Fatal | – | – | – | – |
| Serious | – | – | – | – |
| Minor | – | – | – | Not applicable |
| None | 2 | 2 | 4 | Not applicable |

## 1.3 Damage to the aircraft

None.

## 1.4 Other damage

None.

## 1.5 Personnel information

### *1.5.1 Commander*

The Commander was 59 years old at the time and had a valid ATPL[11].

| Flying hours | | | | |
|---|---|---|---|---|
| Latest | 24 hours | 7 days | 90 days | Total |
| All types | 1.9 | 5.8 | 13.7 | 23211 |
| This type | 1.9 | 5.8 | 13.7 | 3740 |

Number of landings this type previous 90 days: 16.
Type rating concluded on 20 February 1995.
Latest PC (Proficiency Check) carried out on 23 June 2010 on the type.

[11] ATPL: Airline Transport Pilot License, with authorization to act as commander

### 1.5.2 Co-pilot

The Co-pilot was 26 years old at the time and had a valid CPL[12].

| Flying hours | | | | |
|---|---|---|---|---|
| Latest | 24 hours | 7 days | 90 days | Total |
| All types | 1.9 | 5.8 | 47 | 1140 |
| This type | 1.9 | 5.8 | 47 | 240 |

Number of landings this type previous 90 days: 38.
Type rating concluded on 5 May 2008.
Latest PC was conducted on 23 June 2010 on the type.

### 1.5.3 The pilots' duty schedule

Both pilots had an accumulated duty time of 24 hours for the last 7-day period.

## 1.6 Aircraft information

### 1.6.1 Airworthiness and maintenance

| **Aircraft** | |
|---|---|
| TC-holder | Raytheon Beechjet |
| Model | 400A |
| Serial number | RK-37 |
| Year of manufacture | 1992 |
| Gross mass | Max authorized take off/landing mass 7300/7120 kg, actual 6985 kg |
| Centre of gravity | Within limits |
| Total flying time | 3343 hours |
| Flying time since latest inspection | 134 hours (B-check) |
| Number of cycles | 3686 |
| Fuel loaded before event | 1818 kg |
| **Outstanding remarks** | |
| MEL/HIL | No outstanding remarks with regard to the avionics system or aids to navigation. |

The aircraft had a Certificate of Airworthiness and a valid ARC [13].

### 1.6.2 Navigation systems

The aircraft was equipped as standard with duplicated systems for navigation and flight information. Information to the navigation systems come from various sources including the two navigation computers designated FMC[14]. The aircraft's FMCs include databases containing all the necessary flight operational information for the planning and execution of the flight. The system also includes a computer (MDC[15]) that monitors the operation of certain navigation systems.

[12] CPL: Commercial Pilot Licence
[13] ARC: Airworthiness Review Certificate
[14] FMC: Flight Management Computer. Computer that contains the navigation database, among other things.
[15] MDC: Maintenance Diagnostic Computer. Computer that monitors the function of various

The FMC has a battery in order to retain the navigation database and to keep the real-time clock running when the power supply from the aircraft is not available, that is, when the avionics are off. This means that the less the aircraft is used, the more power is taken from the battery. When flying, the computers are powered by the aircraft's power sources. Rockwell Collins[16] has experienced that aircraft have lost the information in the database due to the battery running out.

### 1.6.3 Operation and system maintenance

In March 2006, Raytheon Aircraft Company (TC) issued a bulletin (P/N 128-590001-9 revision C11) which recommended that the batteries in the FMC and MDC should be replaced every four years.

In October 2006, Rockwell Collins published a Service Bulletin (SB 27, revision 2) containing detailed instructions on how to replace and insert an extra battery in the MDC in order to reduce the risk of data being lost due to the battery running out. An equivalent bulletin (SB 25) was issued for the FMC. The measures described in these bulletins are not mandatory but are determined from case to case by the operator or the maintenance organization.

After this incident, the bulletins have been introduced as mandatory in the AMP (Aircraft Maintenance Program) for the aircraft in question. The batteries in SE-DRS were from 1997. Figure 6 shows information from Rockwell Collins on how the life of the batteries varies depending on the aircraft's flying hours per year and on how many batteries are installed.

The idea behind the original design (with only one battery) was that the database should not be lost during flight because the power supply is then secured. It is therefore highly likely that a case in which the battery has run out would be able to be diagnosed when the aircraft is on the ground.

In the present case of SE-DRS, the commander switched off the Avionics Master in the air to try to rectify the faults in the heading information and problems with the database, which also meant that the power supply to the FMC's database then went over to battery. The measure of switching off the Avionics Master upon this type of malfunction is not described in the aircraft's checklists.

| **Flying hours per year** | **Life (years) battery with only one battery** | **Life (years) battery with two batteries** (SB 25 carried out) |
|---|---|---|
| 0-250 | 2 | 4 |
| 250-450 | 4 | 5 |
| 450-700 | 5 | 8 |
| 700-900 | 6 | 9 |
| 900-2000 | 7 | 10 |

Figure 6. Life of batteries in the FMC according to the manufacturer.

avionics systems.

[16] Manufacturer of navigation systems as well as FMC and MDC.

## 1.7 Meteorological information

An area of low pressure with layered clouds and occasional snow covered large parts of Finland on the day in question. Risk of icing in clouds.

## 1.8 Aids to navigation

The navigation aids on ground used during the flight functioned without remark.

## 1.9 Radio communications

The radio communication between the aircraft and air traffic control has been secured. The analysis of the communication verifies the statements given by the crew.

## 1.10 Aerodrome information

Tampere-Pirkkala Airport (landing site) is used for both civilian and military traffic. Procedure and minima for the PAR approach are described in official documentation for the airport.

## 1.11 Flight recorders

Data from the CVR[17] or FDR[18] has not been used in this investigation.

## 1.12 Site of occurrence

### *1.12.1 Site of occurrence*

Shortly after take off from Tallinn and during flight.

## 1.13 Medical information

Nothing indicates that the mental and physical condition of the pilots were impaired before or during the flight.

## 1.14 Fire

There was no fire.

## 1.15 Survival aspects

### *1.15.1 The rescue operation*

No rescue operation was performed.

## 1.16 Tests and research

### *1.16.1 Fault isolation*

The day after the incident, a technician arrived in Tampere-Pirkkala to begin fault isolation. The faults in the heading and attitude information could not be recreated. Initially, the navigation database could not be updated. After having changed places for the two FMC computers, the database could be loaded. The aircraft was then flown in visual conditions to a workshop in Roskilde in Denmark, where the fault isolation continued.

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[17] CVR – Cockpit Voice Recorder. Recording equipment for sound in the cockpit.
[18] FDR – Flight Data Recorder. Recording equipment for flight data.

Despite extensive examination, the faults still could not be recreated. Examination of, among other things, the avionics wires and contacts was carried out. A circuit board in one of the FMC units was also replaced. Rockwell Collins recommended that batteries in the FMC and MDC computers be replaced in order to rectify the problems with the navigation database. After replacing these batteries, the database functioned normally, and the FMC and other avionics functioned without remark.

### *1.16.2 Disturbances in the magnetic field*

Getting a heading split[19] is fairly common at airports where the earth's magnetic field can be distorted. These problems are normally not localized to certain aircraft types, but may, however, be more sensitive on low-wing aircraft where the sensors are closer to the ground. This is due to the distortion of the earth's magnetic field being greater near the surface of the ground, since it is normally in the ground that the metals causing the magnetic field distortion are found.

Figure 7. shows the positions of the flux detectors (sensors) on the aircraft in question.

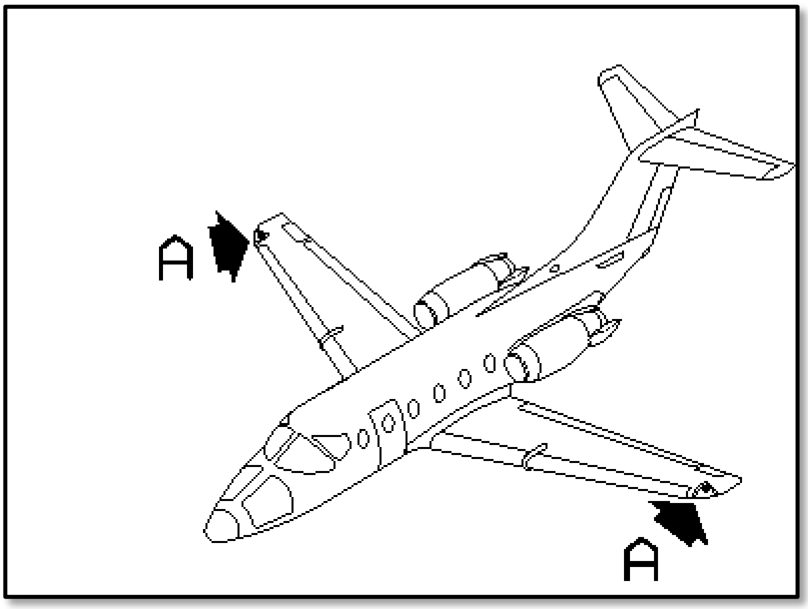


Figure 7. The position of the flux detectors on the Beechjet 400A.

Heading split due to disturbances in the magnetic field is discussed in AAIB[20] Bulletin 1/2008.
The bulletin reports several cases of magnetic disturbances at London City Airport. Measurements of the magnetic field were performed at a holding point where there had been indications of magnetic disturbances. The bulletin discusses six reports from November 2003 to 31 October 2006 where the crew have had problems with the heading systems in the aircraft.

The bulletin establishes that the distortion of the earth's magnetic field which occurs at a certain holding point was the cause of the erroneous readings. The distortion itself was due to the holding point being built in an area where there were old railway tracks under the surface of the ground.

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[19] The two compasses located in the wing tips display different headings.
[20] AAIB, Air Accidents Investigation Branch. The UK accident investigation authority.

### *1.16.3 Interviews*

Interviews have been conducted with the commander and the co-pilot and with the technical staff who carried out fault isolation of the aircraft after the incident. Interviews have also been conducted with the technical staff that had maintenance responsibility for the aircraft.

## 1.17 Organizational and management information

Not applicable.

## 1.18 Additional information

### *1.18.1 Similar events*

In Sweden, there is one confirmed case involving a Beechjet 400A where navigation data disappeared and where the FMC screen went black as a result. The fault occurred on the ground and was rectified by replacing the battery in the FMC.

### *1.18.2 Environmental aspects*

Not applicable.

# 2. ANALYSIS

## 2.1 The flight

After the system had been restarted before the take off from Tallinn, the crew, as reported in the interviews, were confident that no problems with the aircraft's navigation system remained. Therefore, it probably came as a surprise when the faults reappeared during the climb out and, in addition, also comprehended more components in the aircraft's electronic systems.

The commander's decision to switch off the Avionics Master during flight is not included as a measure in any of the aircraft checklists. The measure can be described as a final attempt to resolve the problems with the avionics. The result, however, was not the expected one, and probably made the situation worse.

In light of the prevailing weather situation, the commander's decision to land at a suitable alternate airport with operationally acceptable weather conditions was well founded. The fact that there were good weather conditions at an airport that was also equipped with PAR may be considered to have been a fortunate circumstance that helped to solve the emergency situation.

Even if the weather conditions were acceptable during the approach to Tampere, SHK can note that a PAR approach with only the standby instruments available places high demands on the ability of the pilots. The commander's long experience has probably contributed to the approach and landing being able to be executed without further complications.

## 2.2 Technical faults

There were probably two distinct problem areas during the present flight. There were problems, firstly, with the heading information and, secondly, with the database and the flight plan in the computers.

The crew's problems with the heading information before take off from Tallinn Airport had probably only been matter of sharp variations in the earth's magnetic field at the airport due to a varying quantity of reinforcement in the taxiway's concrete surface. The crew recognized this type of problem and rectified them by restarting the system when they had left the parking place. The fact that these problems reappeared to varying degrees after take off has no direct connection with the FMC problems, and the problems have not been possible to diagnose.

The problems with inserting flight plans and waypoints in the computers did not exist as long as the aircraft was on the ground. When power was removed from the avionics after take off, during the time when the Avionics Master was off, the database became unavailable even after switching on the power, and the presentation on the screens disappeared. This was probably caused by the batteries in the FMC and MDC being virtually drained. In other words, when the power was switched off, there was not enough capacity in the batteries to maintain the information in the database. It had probably not been anticipated that this situation could occur in the air since battery problems should already be diagnosed before flight.

## 2.3 Technology – Navigation equipment

A service bulletin (SB) issued by, e.g., the type certificate holder or manufacturer of a piece of equipment normally specifies how a measure on a piece of equipment or routine is to be performed. The classification states how the measures are to be applied. A common classification system in descending order of implementation requirement is alert, recommended and optional. For equipment manufacturers with TSO authorization or the equivalent, the aircraft's type certificate holder must issue what is known as a “cover bulletin” that indicates measures on, for example, an avionics unit in order to make the measure mandatory. For smaller aircraft, in order for the measure to be mandatory, the civil aviation authority in the country where the design organization operates must issue an Airworthiness Directive (AD), which normally indicates an alert SB where the physical measure is described.

In the present case, there were several SBs that were intended to prevent the batteries from being able to run out, but these had not been implemented on the aircraft in question. This probably implied that the batteries were not replaced in time to prevent the systems in question from losing power during the flight in connection with the Avionics Master being switched off.

# 3 CONCLUSIONS

## 3.1 Findings

*a)* The pilots were qualified to perform the flight.
*b)* The aircraft had a valid Certificate of Airworthiness.
*c)* The compass sensors can be disrupted by the presence of metal near the surface of the ground during taxiing.
*d)* The navigation system was restarted on the ground before take off.
*e)* The navigation system was restarted in the air.
*f)* The aircraft checklists do not contain any directions for switching off the Avionics Master in the air.
*g)* The aircraft had to be operated by means of standby instruments.
*h)* Approach and landing were executed by means of radar guidance (PAR).
*i)* Bulletins from the avionics manufacturer regarding installation of an additional battery in the FMC and MDC were not mandatory and had not been followed.

## 3.2 Causes

The incident was caused by that the measures that were recommended to solve the known deficiencies in the power supply to the navigation computer system neither were mandatory nor had been performed.

# 4. RECOMMENDATIONS

None.