Statens haverikommission
Swedish Accident Investigation Authority

Final report RL 2019:07e

Accident in Othem, Gotland, on 11 August 2018 involving aircraft D-EHAC of the model Bölkow BO 208 C Junior , operated by a private individual.

File no. L-98/18

6 May 2019

SHK investigates accidents and incidents from a safety perspective. Its investigations are aimed at preventing a similar event from occurring in the future, or limiting the effects of such an event. The investigations do not deal with issues of guilt, blame or liability for damages.

The report is also available on SHK´s web site: www.havkom.se

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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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Content

General observations

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 to clarify, as far as possible, the sequence of events and their causes, as well as damages and other consequences. The results of an investigation shall provide the basis for decisions aiming at preventing a similar event from occurring in the future, or limiting the effects of such an event. The investigation shall also provide a basis for assessment of the performance of rescue services and, when appropriate, for improvements to these rescue services.

SHK accident investigations thus aim at answering three questions: *What happened? Why did it happen? How can a similar event be avoided in the future?*

SHK does not have any supervisory role and its investigations do not deal with issues of guilt, blame or liability for damages. Therefore, accidents and incidents are neither investigated nor described in the report from any such perspective. These issues are, when appropriate, dealt with by judicial authorities or e.g. by insurance companies.

The task of SHK also does not include investigating how persons affected by an accident or incident have been cared for by hospital services, once an emergency operation has been concluded. Measures in support of such individuals by the social services, for example in the form of post crisis management, also are not the subject of the investigation.

Investigations of aviation incidents are governed mainly by Regulation (EU) No 996/2010 on the investigation and prevention of accidents and incidents in civil aviation and by the Accident Investigation Act (1990:712). The investigation is carried out in accordance with Annex 13 of the Chicago Convention.

The investigation

SHK was informed on 11 August 2018 that an accident involving one aircraft with the registration D-EHAC had occurred in Othem in Gotland County, on the same day at 12:00 hrs.

The accident has been investigated by SHK represented by Mr Mikael Karanikas Chairperson, Mr Nicolas Seger, Investigator in Charge, and Mr Ola Olsson, Technical Investigator (aviation).

The investigation team of SHK was assisted by Ms Camilla Söderström, Element Materials Technology AB, as an expert specializing in materials.

Mr Jens Eisenreich has participated as the accredited representative on behalf of German Federal Bureau of Aircraft Accident Investigation (BFU).

Germany's accredited representative was assisted by three advisors on behalf of the type certificate holder Airbus Defence and Space GmbH, Mr Ulrich Hagmann, Mr Robert Reutter and Mr York Weber.

The investigation was followed by Ms Raluca-Maria Negoescu, as the advisor from the European Aviation Safety Agency (EASA).

The investigation was followed by Mr Magnus Axelsson, as the advisor from the Swedish Transport Agency (Transportstyrelsen).

The following organisations have been notified: EASA, the European Commission, BFU and the Swedish Transport Agency.

Investigation material

Interviews have been conducted with the pilot and the airfield owner.

Parts of the nose landing gear have been taken in for examination.

A meeting with the interested parties was held on 10 December 2018. At the meeting SHK presented the facts discovered during the investigation, available at the time.

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Aircraft:	
Registration, type	D-EHAC, Bölkow BO 208
Model	Bölkow BO 208 C Junior
Class, Airworthiness	Normal, Certificate of Airworthiness and Valid Airworthiness Review Certificate (ARC)[1]
Serial number	709
Owner	Private
Time of occurrence	11/08/2018, 12:00 hrs in daylight Note: All times are given in Swedish daylight-saving time (UTC[2] + 2 hours)
Place	Othem, Gotland County, (position 5745N 01844E, 36 metres above mean sea level)
Type of flight	Private
Weather	According to SMHI's analysis: wind S to SW/10–12 knots, visibility >10 kilometres, cloud 0–3/8 with base at 3,000–4,000 feet, temperature/dewpoint +21/+10 °C, QNH[3] 1017 hPa
Persons on board:	1
crew members	1
passengers	None
Injuries to persons	None
Damage to aircraft	Substantially damaged
Other damage	None
Pilot in command:	
Age, licence	48 years, PPL(A)[4]
Total flying hours	217 hours, of which 12 hours on type
Flying hours previous 90 days	41 hours, of which 9 hours on type
Number of landings previous 90 days	25, of which 10 on type

[1] ARC (Airworthiness Review Certificate).
[2] UTC (Coordinated Universal Time).
[3] QNH (Barometric pressure reduced to mean sea level).
[4] PPL (Private Pilot License).

SUMMARY

The accident occurred on 11 August 2018 in conjunction with a landing at a private airfield at Othem in Gotland. The aircraft was a model Bölkow BO 208 C Junior. The pilot was alone on board.

According to the pilot, the aircraft bounced during the landing, after which the touchdown occurred on all three wheels. After rolling approximately 200 metres, the nosewheel came off, the aircraft nosed over and ended up on its back. The pilot was able to leave the aircraft unharmed, whereas the aircraft sustained substantial damage.

An investigation of the nose landing gear has shown that a gas spring had been replaced with a spring assembly which meant that the nose landing gear was completely without damping. Calculations showed that the nose landing gear was subjected to a vertical force equivalent to 3.4 G, which is a very hard landing.

The accident was caused by a hard landing on an uneven runway, in combination with the lack of a damping function in the nose landing gear.

Safety recommendations

None.

1. FACTUAL INFORMATION

1.1 History of the flight

1.1.1 Preconditions

The flight started from Visby Airport in Gotland. The destination was a private airfield near Othem, which is around 25 kilometres northeast of Visby.

As the pilot had not previously landed on this airfield, he first went to the site by car to explore the area. He estimated that the grass runway was 700 metres long and 40 metres wide.

1.1.2 History of the flight

The pilot has said that the approach was made in a westerly direction to runway 27. An initial touchdown of the main wheels occurred roughly 100 metres into the runway, at an indicated speed of 65 knots. Since the aircraft made a low bounce, the pilot opened the throttle and landed on all three wheels after a few metres. After rolling 200 metres, the nose-wheel came off. After another 20 metres, the aircraft flipped over and ended up on its back.

The pilot turned off all relevant switches, kicked open the hood and exited the aircraft unharmed.

The accident occurred at 12:00 hrs in daylight at position 5745N 01844E, 36 metres above mean sea level.

1.2 Injuries to persons

	Crew members	Passengers	Total on-board	Others
Fatal	-	-	0	-
Serious	-	-	0	-
Minor	-	-	0	Not applicable
None	1	-	1	Not applicable
Total	1	0	1	-

1.3 Damage to aircraft

Substantially damaged.

1.4 Other damage

None.

1.4.1 Environmental impact

Limited fuel spill.

1.5 Personnel information

1.5.1 Qualifications and duty time of the pilot

Pilot in command

The pilot in command was 48 years old and had a valid PPL(A) license with flight operational and medical eligibility.

Flying hours				
Latest	24 hours	7 days	90 days	Total
All types	3	4	41	217
Actual type	1	2	9	12

Number of landings actual type previous 90 days: 10.
Type rating conducted on 2 June 2017.
Latest PC[5] conducted on 6 August 2018 on actual type.

1.6 Aircraft information

Bölkow BO 208 C Junior is a single-engine, two-seater, high-wing aeroplane mainly made of metal, with wing struts and fixed landing gear and nosewheel (see figure 1).

The aircraft is 5.79 metres long with a span of 8.02 metres.

Figure 1. Aeroplane D-EHAC. Photo: Aeroplane owner.

[5] PC (Proficiency Check).

1.6.1 Aeroplane

Type certificate holder	Airbus Defence and Space GmbH
Model	Bölkow BO 208 C Junior
Serial number	709
Year of manufacture	1971
Gross mass (kg)	Max. authorised gross mass 630, actual gross mass 515
Centre of gravity	Within permitted limits
Total flying hours	2,111
Flying time since last periodic inspection (hours)	7
Type of fuel loaded prior to the occurrence	100LL
Engine	
Type certificate holder	Continental Motors, Inc.
Engine type	Continental O-200-A
Propeller	
Type certificate holder	McCauley Propeller Systems
Type	1A100MCM 6955
Deferred remarks	None

The aircraft had a Certificate of Airworthiness and a valid ARC.

1.6.2 Description of parts or systems related to the occurrence

Nose landing gear

The aeroplane has a steerable nosewheel. The nose landing gear consists of a landing gear leg with attachments, a steering rod, a torque link consisting of two leaf springs, a fork and a nosewheel with fairing.

The landing gear leg consists of an outer cylinder and an inner piston rod. The nosewheel fork is mounted on the lower end of the piston rod.

The torque link has three functions: It provides springing, prevents torsion between the landing gear leg and the nosewheel fork, and it enables transfer of steering inputs.

There are two different nose landing gear models for the Bölkow BO 208 C Junior. Aircraft up to serial number 680 were fitted with a model with internal coil springs in the landing gear leg, combined with an externally mounted hydraulic damper (see figure 2).

The internal components consist of four coil springs: two of a larger diameter and two with a smaller diameter. The two smaller springs are placed inside the larger ones. On top of the spring pile, there is a bushing and a metal rod creating a distance between the spring assembly and the top of the cylinder.

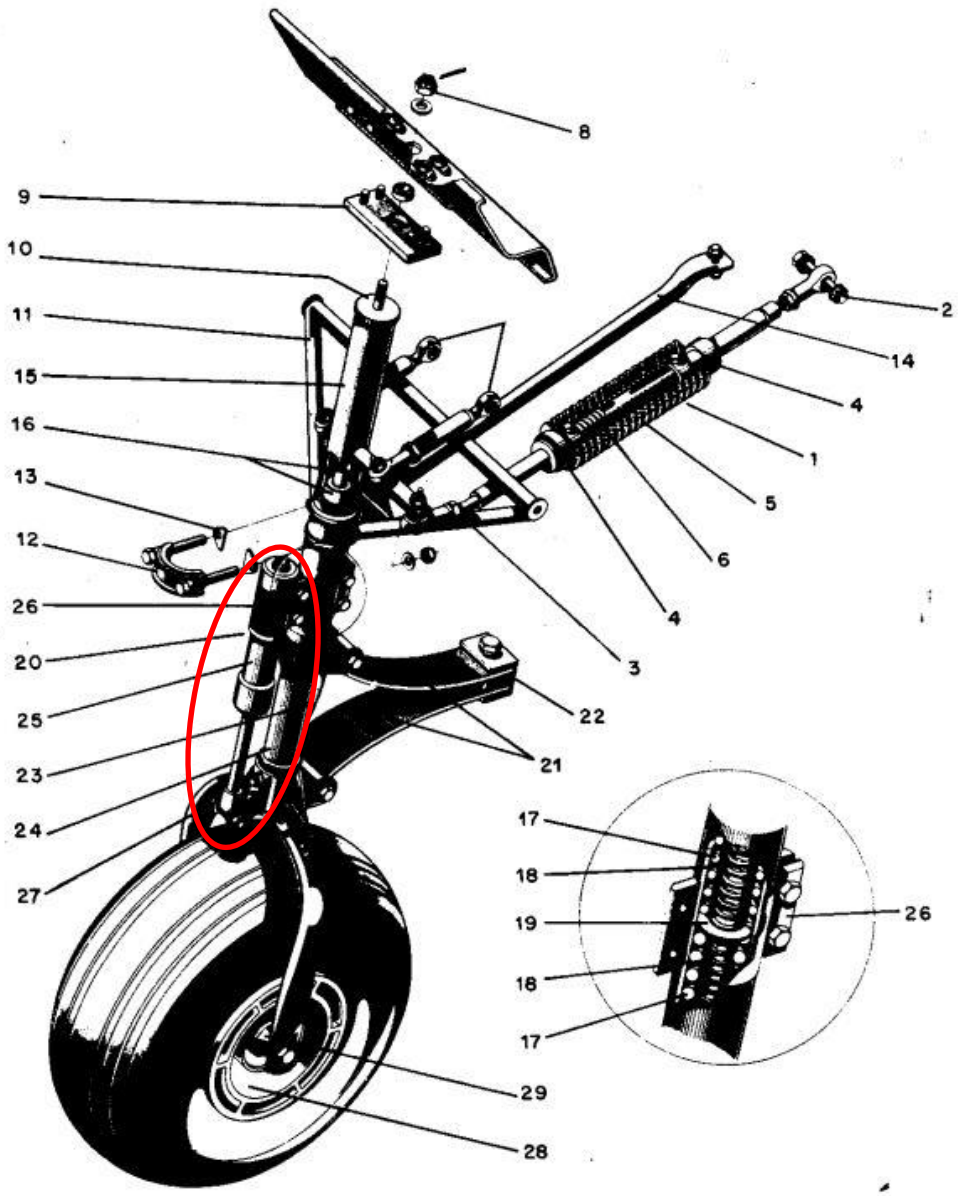

Figure 2. Nose landing gear with external damper circled in red. The torque link is marked with numbers 21 and 22. Illustration: Airbus Defence and Space GmbH.

From serial number 681 and onward, the design of the landing gear leg cylinder was changed, which meant that the coil springs were replaced by an internal gas spring. In the later design, the gas spring acts as both springing element and damper (see figure 3).

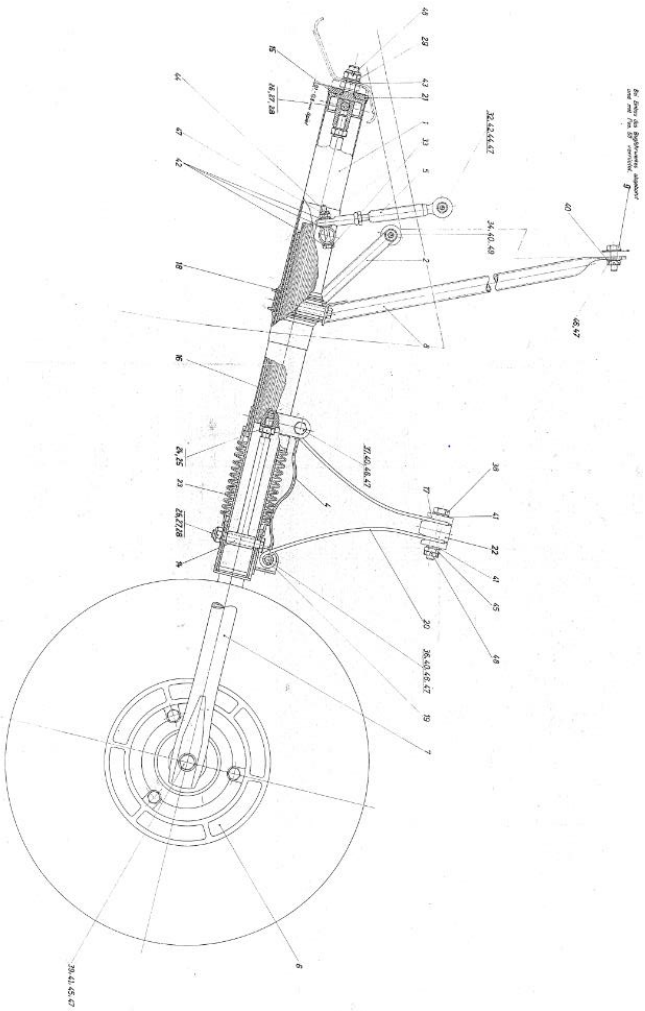

Figure 3. Landing gear leg with internal gas spring. Illustration: Airbus Defence and Space GmbH.

The investigation of the nose landing gear is described in sections 1.16.2 and 1.16.3.

1.7 Meteorological information

According to SMHI's analysis: Wind S to SW/10–12 knots, visibility >10 kilometres, cloud 0–3/8 with base 3,000–4,000 feet, temperature/dewpoint +21/+10 °C, QNH 1017 hPa.

The accident occurred in daylight.

1.8 Aids to navigation

Not applicable.

1.9 Communications

Not applicable.

1.10 Aerodrome information

The airport is a private grass field.

According to SHK's measurements, the field was 580 metres long and 40 metres wide at the narrowest point. Two filled ditches crossed the field, where the surface had unevenness that were five to ten centimetres deep along a horizontal distance of one to two metres.

Chapter 3, Section 2 of the Swedish Transport Agency's regulations and guidance material (TSFS 2010:123) on the design and operations of airports that do not require a certification states that the surface evenness of a runway must be such that an aircraft can be operated on the runway without inconvenience.

1.11 Flight recorders

Not required and not available on board.

1.12 Accident site and aircraft wreckage

1.12.1 Accident site

The accident site is a private airfield near Othem in Gotland.

The image in figure 4 shows the approximate ground roll of the aircraft and the site of the accident marked with an X in red. The ditches that can be seen in the image were filled at the time of the accident.

Figure 4. The aircraft's ground roll and the accident site. Map from Google Earth: © Lantmäteriet Ref. no. R61749_190001.

The aircraft ended up on its back. The nosewheel can be seen at the bottom of the image in figure 5.

Figure 5. The nosewheel and the aircraft wreckage. The picture is taken in an easterly direction. Photo: Aeroplane owner.

1.12.2 Aircraft wreckage

Figure 6. The wreckage after being towed to the hangar.

The aircraft had visible damage to the following components:

- Propeller and spinner
- Engine cowling
- Nose landing gear
- Nosewheel fairing
- Windshield and roll bar
- The rear attachment, tip and flap of the left wing
- The top part of the elevator and the fin
- The tailskid and its attachment

There were also traces of paint on both sides of the nosewheel tyre, which shows that the tyre has come into contact with the wheel fairing (see figure 7).

Figure 7. Traces of paint from the wheel fairing on the tyre.

The bottom part of the nose landing gear had separated from the aircraft, with fracture surfaces on both the piston rod and the leaf spring (see figure 8).

Figure 8. The top part of the nose landing gear.

Relevant parts were taken for further examination. The examination is reported in section 1.16.3.

1.13 Medical and pathological information

There is nothing to indicate that the mental and physical condition of the pilot was impaired before or during the flight.

1.14 Fire

No fire broke out.

1.15 Survival aspects

1.15.1 Rescue operation

No rescue operation was initiated.

The ELT[6] was not activated.

[6] ELT (Emergency Locator Transmitter).

1.15.2 Position of crew and passengers and the use of seat belts

The pilot, who was alone on board, was sitting in the left seat wearing a four-point seat belt. The pilot was able to exit the aircraft on his own, without any injuries

1.16 Tests and research

1.16.1 Performance

Using the aircraft flight manual, SHK has calculated that the necessary landing distance over a 50-foot obstacle was 460 metres. The normal approach speed is specified in the manual as 65 knots at full flap.

The maximum allowable crosswind component is 20 knots according to the flight manual.

1.16.2 Material examination of the nose landing gear

SHK has submitted the leaf spring and the piston rod to a laboratory for a fracture analysis.

The aim of this analysis has been to determine which type of fracture the leaf spring and piston rod were subjected to, and to investigate possible causes of these fractures.

The leaf spring had several fatigue cracks and several surface defects that have given rise to fatigue cracks. The damper piston has ruptured due to overloading, and the fracture surface shows that the nosewheel was oriented in the direction of travel at the time of the rupture.

1.16.3 Examination of the nosewheel components

The examination of the nose landing gear showed that the external cylinder was modified in such a way that is not in accordance with any of the type certificate owner's models.

The part was similar to the latter model, which normally has an internal gas spring. However, after disassembly, it was discovered that coil springs were installed while the gas spring was missing. There was also a metal rod and a bushing.

The lower part of the piston rod had broken off. The remaining part was bent and stuck in the cylinder in the fully compressed position.

The upper leaf spring of the torque link had ruptured close to the rear attachment and was deformed.

The metal bar in the cylinder was deformed (see figure 9). SHK estimates that the bar had been subjected to a buckling load equivalent to a G-force of 3.4 G.

Figure 9. Part of the spring assembly and the deformed metal rod.

1.16.4 Maintenance history of the nose landing gear

The aircraft maintenance documents contained the following information regarding maintenance measures in relation to the nose landing gear.

- 11 May 1979: Defect in the nose landing gear gas spring. Gas spring replaced.
- 25 May 1981: Outer cylinder on the nose landing gear has been changed.
- 11 December 1998: Nose landing gear repaired.

An airworthiness directive (LTA[7] 1972-092) stipulates that the outer cylinder of the nose landing gear must be inspected every twelve months to discover any cracks. Such an inspection was last performed on 11 June 2018 without remark.

1.17 Organisational and management information

Not applicable.

1.18 Additional information

Not applicable.

1.19 Special methods of investigations

Not applicable.

[7] LTA (Lufttüchtigkeitsanweisung).

2. ANALYSIS

2.1 Preconditions

The flight started from Visby Airport to then fly to Othem, which is located northeast of Visby. As the pilot had not previously landed in this destination, he first went to the site by car to explore the area. He estimated that the grass runway was 700 metres long and 40 metres wide. According to SHK's measurements, the field was 580 metres long and 40 metres wide at the narrowest point, which meets the performance requirements in the flight manual.

SHK's examination of the field showed that it was crossed by a filled ditch, where the surface had unevenness that were five to ten centimetres deep along a horizontal distance of one to two metres. Chapter 3, Section 2 of the Swedish Transport Agency's regulations and general advice (TSFS 2010:123) on the design and operations of airports that do not require a certification states that the smoothness of a runway must be such that an aircraft can be operated on the runway without inconvenience. However, SHK believes that the unevenness in the runway in question were such that they could contribute to bouncing in conjunction with take-off and landing.

2.2 Sequence of events

The pilot has stated that the approach was made in a westerly direction to runway 27, and that an initial touchdown of the main wheels occurred roughly 100 metres into the runway at a speed of 65 knots. Since the aircraft made a low bounce, the pilot opened the throttle, and landed on all three wheels after a few metres. After rolling approximately 200 metres, the nosewheel came off. After another 20 metres, the aircraft flipped over and ended up on its back.

According to SMHI's analysis, the wind direction was south-southwest, with a wind speed of 10–12 knots, which means that the landing was carried out with a crosswind component that was lower than the maximum allowable level of 20 knots according to the flight manual. The approach was made at full flap and at a speed of 65 knots, which is also in accordance with the flight manual.

2.3 Nose landing gear

SHK's examinations have shown that the aircraft's nose landing gear did not correspond to the TC-holder's specification.

The nose landing gear design was not in accordance with the drawings. The gas spring normally installed in the landing gear cylinder was replaced with a coil spring assembly along with a rod and bushings. It is possible that the internal parts of the landing gear originate from the earlier model.

It has not been possible to establish by means of the aircraft's maintenance documents when or why the gas spring was replaced with the coil spring assembly. The aircraft owner was unaware of the change.

The incorrect composition of the nose landing gear has led to a complete lack of damping, which has contributed to the aircraft bouncing in conjunction with the landing.

The investigation of the damages to the nose landing gear (see sections 1.16.2 and 1.16.3) has shown that it was completely compressed during the landing. SHK has calculated that the nose landing gear was subjected to a vertical force equivalent to 3.4 G, which means that it was a very hard landing. In addition, the paint residue on the tyres indicates that there was significant force applied to the nosewheel during landing.

SHK therefore makes the assessment that the fracture on the nose landing gear was caused by several factors, namely a hard landing, the unevenness on the runway and the fact that there was no damping on the nose landing gear.

SHK believes that the piston rod was fractured first due to overload, and that the leaf spring unit then broke off when the lower part of the nose landing gear bent backwards. This is confirmed by the marks on the back of the landing gear cylinder and by the deformation of the upper leaf spring.

The pilot was wearing a four-point seatbelt, which contributed to saving him from sustaining any injuries.

3. CONCLUSIONS

3.1 Findings

a) The pilot was qualified to perform the flight.
b) The aircraft had a Certificate of Airworthiness and valid ARC.
c) The nose landing gear was modified in a way which did not correspond to the TC-holder's specification.
d) There was no damping on the nose landing gear.
e) The runway was uneven.
f) It was a very hard landing.
g) The lower part of the nose landing gear had separated from the aircraft, and it had fracture damage both on the piston rod and on the leaf spring.
h) The aircraft flipped forwards and landed upside down.
i) There was substantial damage to the aircraft.
j) The pilot was unharmed.

3.2 Causes/Contributing Factors

The accident was caused by a hard landing in combination with an uneven runway and the lack of a damping function in the nose landing gear.

4. SAFETY RECOMMENDATIONS

None.

On behalf of the Swedish Accident Investigation Authority,

Mikael Karanikas Nicolas Seger