Statens haverikommission
Swedish Accident Investigation Authority

ISSN 1400-5719

Final report RL 2012: 07e

Serious incident on 5 February 2011 with the aircraft D-ABGQ at Arlanda airport, Stockholm County.

Case L-08/11
2012-03-05

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

In case of discrepancies between English and Swedish language versions of a report, the Swedish text shall prevail in the interpretation of the report.

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Statens haverikommission
Swedish Accident Investigation Authority

Swedish Transport Agency

601 73 NORRKÖPING

Final report RL 2012: 07e

The Swedish Accident Investigation Authority (SHK) has investigated a serious incident that occurred on February 5 2011 at Arlanda airport in Stockholm County, involving an aircraft with the registration D-ABGQ.

In accordance with Regulation (EU) No 996/2010 on the investigation and prevention off accidents and incidents in civil aviation the SHK investigation team hereby submits a report on the investigation.

SHK would be grateful to receive, by 15 may 2012 at the latest, information regarding measures taken in relation to the recommendations included in this report.

On behalf of SHK investigation team

Jonas Bäckstrand

Stefan Christensen

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Contents

General

The Swedish Accident Investigation Board (Statens haverikommission – SHK) is an independent government 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 other effects. 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, as well as for an assessment of the operations performed by the emergency services in respect of the event and, as the case may be, for improvements to these emergency services.

SHK accident investigations 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. Such issues are therefore, neither investigated nor described in the reports. They may on the other hand be dealt with by judicial authorities or, for example, by insurance companies.

The task of SHK also does not cover 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 do not form part of the task of SHK.

The investigation of aviation incidents are governed mainly by 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 Annex 13 of the Chicago Convention.

The investigation has been limited to not include rescue services or technical details of the aircraft. Nor does the inquiry cover the aircraft that was taking off on the on the runway and which came into conflict with the investigated aircraft.

The investigation

On 10 February 2011 SHK was informed that a serious incident (henceforth named the incident or the occurrence) involving one aircraft with registration D-ABGQ had occurred at Arlanda airport, Stockholm County, on February 5, at 11.25.

The incident has been examined by an SHK investigation team, consisting of Mr Göran Rosvall, Chairperson until 2011-01-26, there after Mr Jonas Bäckstrand, Chairperson, Mr Stefan Christensen, Investigator in Charge, and Ms Ulrika Svensson, Operations Investigator.

The investigation has been followed by Mr Anders Petersson from the Swedish Transport Agency.

Final report RL 2012:07e

Aircraft: registration, model	D-ABGQ, A319-112
Class/Airworthiness	Normal, airworthiness certificate with valid ARC[1]
Owner/Operator	Air Berlin, NIKI Luftfahrt GmbH, LTU and Belair/Air Berlin
Time of incident	05/02/2011, at.11.25 in daylight Note: All times refer to Swedish standard time (UTC + 1 hour)
Place	Arlanda airport, Stockholm County, (pos. 5938. 7N 01756. 1E; 42 m above sea level)
Type of flight	Commercial air transport
Weather	According to the SMHI analysis: Wind W-SW 5-10 knots, visibility 10 km, 2-6/8 with base 7000 ft, temp./dewpoint 1/-1°C, QNH 984 hPa
Persons on board: Crew	5
Passengers	98
Injuries to persons	None
Damage to aircraft	None
Other damage	None
Commander:	
Age, licence	36, ATPL[2](A)
Total flying time	8,500 hours, of which 3,402 hours on type
Flying hours previous 90 days	144 hours on current type
Number of landings previous 90 days	44 on current type
Co-pilot	
Age, licence	
Total flying time	38, CPL[3](A) 2,832 hours, of which 411 hours on type
Flying hours previous 90 days	75 hours on current type
Number of landings previous 90 days	22 on current type

Summary

The occurrence took place at Arlanda airport on February 5 2011.

A foreign aircraft received a clearance other than standard to taxi from stand 66 to holding position runway 19R. As the aircraft was to turn away from taxiway D north onto taxiway Y, the aircraft continued straight ahead along the line the pilots were following. The aircraft ended up on intersection Y3 leading onto runway 01L, which is the same physical runway as 19R.

[1] ARC – Airworthiness Review Certificate
[2] ATPL – Air Transport Pilot Licence
[3] CPL – Commercial Pilot Licence

Another aircraft was taking off on runway 19R at the same time as the first aircraft passed holding position Y3, and the aircrafts thereby came into conflict with one another.

The taxi mistake came to be serious when the markings to indicate to the pilots that they are at a holding position were missing at the intersection.

The following factors contributed to the occurrence:

- The taxi clearance did not follow the published standard route.
- Holding position marking was missing at Y3.
- An older, no longer valid daylight marking (yellow painted line) in level with the RGL, was perceived as holding position marking for Y3.
- The holding position marking was not consistent with the pilots' taxiway chart, which was based on the AIP.

The occurrence, a runway incursion, is classified as a serious incident in accordance with ICAO Annex 13.

Recommendations

It is recommended that the Swedish Transport Agency should

- in the context of its regulatory work, in particular examine the implementation, operation, and compliance with the system for safety management at Swedish airports. (RL 2012: 07 R1).

- in its ordinary regulatory work, perform a special review of materials relevant for airports in AIP Sverige/Sweden. (RL 2012: 07 R2).

- ensure that Arlanda airport introduces recurrent quality controls of visual aids for navigation at the airport.
  (RL 2012: 07 R3).

1. FACTUAL INFORMATION

1.1 History of the flight

1.1.1 Conditions

On the day in question there was a west-southwest wind, visibility was good and the temperature was + 1 degree Celsius.

Arlanda airport has three runways which within the Arlanda organization are called runways one, two and three. Runway one (01L/19R) is in the northwest and has a north-south direction, runway two (08/26) is in the east-west direction and runway three (01R/19L) in the southeast is also in the north-south direction.

Fig. 1 Arlanda airport

The runway used for takeoff was 19R. The numbering of the runways depends on their respective directions. The direction is rounded off to the nearest ten, so the first two digits of the degrees are the designation of the runway. If two or more parallel runways exist, a letter is added to describe whether it is the left, centre or right runway. Thus, 19R is the right of two runways with an approach path of 185 degrees.

1.1.2 Incident, general

The incident involved two aircrafts, one of which was on runway 19R for takeoff and the other was going to taxi from the apron at the terminal to the holding position for the same runway.

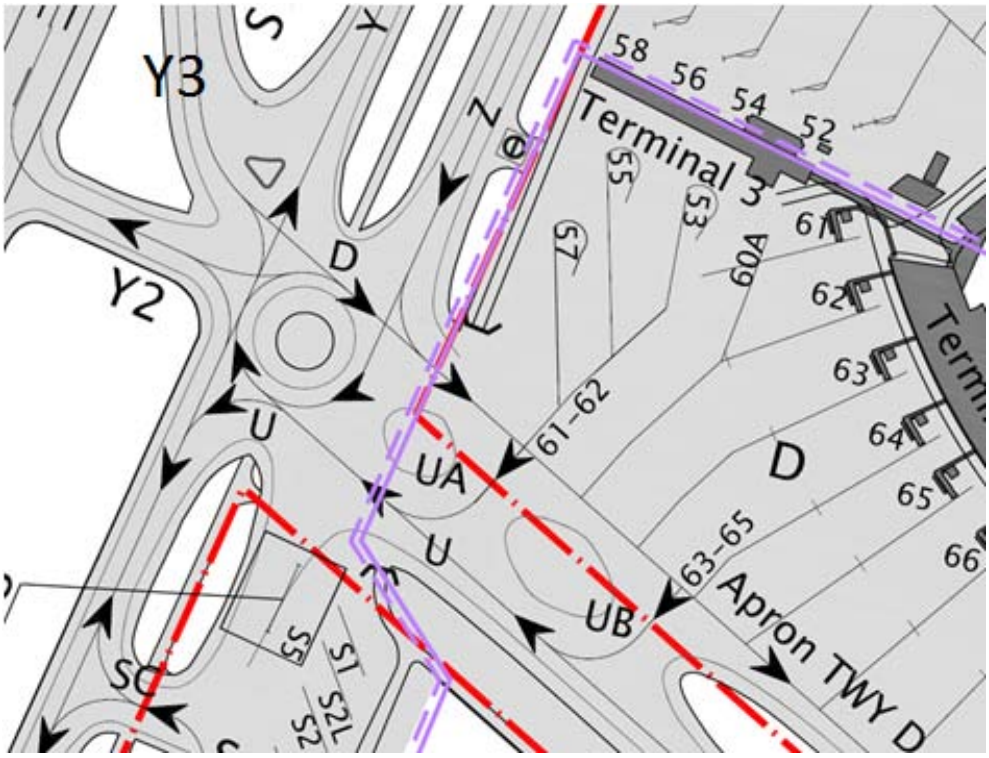

Fig. 2 Excerpts from AIP Sweden/Sweden with published taxi routes (black arrows) for outbound aircraft.

The aircraft D-ABGQ, which was at stand 66, had just received push-back[4] from its gate and requested taxi clearance. The clearance obtained was as follows:

"Air Berlin 758 Mike, taxi to holding point 19R, Delta approved."

The pilots read back:

"Air Berlin 758 Mike, taxi to holding point 19R."

Taxi routes for outbound aircraft are published in AIP Sweden/Sweden on page AD 2-ESSA-2-8 (see fig. 2). The published taxiway out from stand 66 is UC, which is followed by a right turn out onto U and later a right onto Y. Taxiway Y then continues parallel to runway 01L/19R to the holding position 19R.

Taxiway D is used in accordance with AIP Sverige/Sweden for inbound taxiing aircraft, but since D is located closer to the apron area, this route is shorter than U. At times of low traffic, it is customary for air traffic controllers to offer outbound taxiing aircraft the shorter taxiway as a service.

The aircraft turned right and commenced taxiing on taxiway D. After having crossed taxiway Z the intention was that the aircraft would turn right onto taxiway Y. At the area where D stops you can choose to taxi north or south on Y, and to taxi into two different exits to runway 01L/19R. These are numbered Y2 and Y3 and are also marked as holding positions. Y3 continues straight ahead from taxiway D and becomes an extension of the taxiway marking, and then connects to runway 01L/19R.

When the aircraft approached the area where the taxiways met, it went straight on to Y3. In addition to signs on either side of Y3 there was also an illuminated stop bar, which was crossed. As a final protection against intru-

[4] Push-back – Backing of aircraft from gate by another vehicle.

sions on the runway, there were flashing yellow RGL[5], with two lights to the right and two to the left of the taxiway. Next to the RGL there was also a yellow daylight marking; the no longer relevant holding position marking for the former CAT I holding position, which was located between the lamps on either side of the taxiway.

The controller saw visually that the aircraft was on the entry to a runway in use and called, "Air Berlin, hold position". In the interviews with the controller and the pilots they all said they discovered the error in taxiing at the same time.

At the same time as the aircraft approached the runway, another aircraft was about to take off on runway 19R. During initial acceleration, at a speed of 120 to 130 knots, the pilots in the aircraft taking off observed the taxiing aircraft approximately 500 meters ahead. At the same time, the controller ordered the taxiing aircraft to hold its position. After the occurrence, the commander of the aircraft taking off sent an occurrence report in which he stated there would have been a high risk of collision if D-ABGQ had not stopped on the taxiway.

When the runway was free the pilots in the taxiing aircraft received a new clearance in which they were authorized to taxi onto the runway to their starting position.

The incident occurred at position 5938.7N 01756.1E at 42 m above sea level.

1.1.3 Sequence of events – the aircraft D-ABGQ

The pilots of D-ABGQ had landed at Stockholm Arlanda airport the evening before the occurrence, but this was the first time they were to take off from the airport. The crewmembers were experienced and were accustomed to flying at major airports. The commander, who was sitting to the left, was going to taxi out and the co-pilot in the right hand seat was assisting with navigation and also had the published taxiing instructions up on his EFB[6] (LIDO[7]).

Taxi clearance is usually given after push-back, which also happened this time. The pilots were offered the shorter taxi route out from the apron to the taxiways, accepted this and started taxiing in a westerly direction on D.

When the aircraft approached the area where it was going to turn right onto Y, it continued forwards on Y3. The co-pilot informed the commander that they were headed towards a runway and the commander braked the aircraft in front of the yellow holding position mark. At the same time as the crew discovered that they were on the intersection to the runway, the order came from air traffic control to hold their position, which the crew read back correctly.

[5] RGL – Runway Guard Lights – Lights for runway in use – Two yellow lamps on either side of the taxiway that flash yellow.
[6] EFB – Electronic Flight Bag – Digital system, including maps presented on screens.
[7] LIDO – Lufthansa Integrated Dispatch Operation

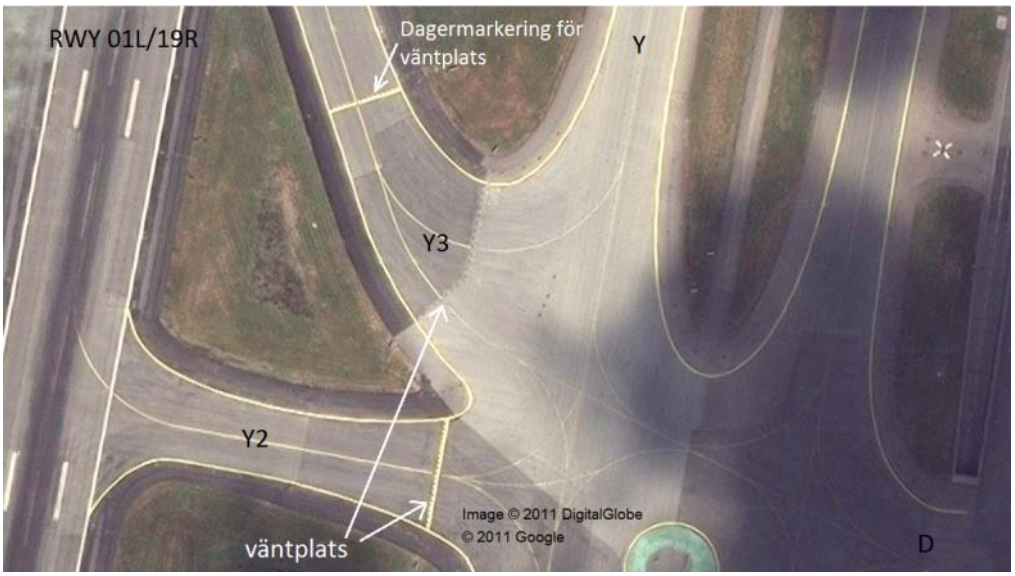

Fig. 3 Google Earth 07/10/2011. The photograph was taken on 06/06/2010.

During the interview with one of the pilots, he said that they were not involved in a runway incursion since they had clearly stopped before the holding position marking. The pilots had not seen the illuminated stop bar. Some time later, the pilots were at Arlanda again and taxied northwards on Y. When they passed the stop bar in question they noticed in particular that it was illuminated.

1.1.4 Sequence of events – air traffic control

The controller in position, i.e. the air traffic controller who was handling radio traffic with the taxiing aircraft, was acting as a student with an instructor. The controller had many years of experience, but had just returned to service after a period of absence. The instructor had the actual responsibility and was supervising the controller, who was training in order to renew the qualification.

The controller said that the aircraft was given the clearance mentioned and then started taxiing, but that the aircraft had not turned onto Y northwards. The controller noticed that the aircraft was on the way out to an active runway, and called out, "Air Berlin, hold position."

The instructor said that he noticed the incident at the same time as the controller called out to the aircraft.

1.2 Injuries to persons

	Crew members	Passengers	Total	Other
Fatalities	–	–	–	–
Seriously injured	–	–	–	–
Slightly injured	–	–	–	Not applicable
No injuries	5	98	–	Not applicable
Total	5	98	–	–

1.3 Damage to aircraft

None.

1.4 Other damage

None.

1.5 Crew members

1.5.1 Commander

The commander was 36 at the time and held a valid ATPL. At the time of the incident the commander was PF[8].

Flying time (hours)				
Previous	24 hours	7 days	90 days	Total
All types	4	20	144	8500
Current type	4	20	144	3173

Number of landings on type, previous 90 days: 44.
Training on type was completed on 27 October 2006.
Latest PC (proficiency check) took place on 8 April 2010.

1.5.2 Co-pilot

The co-pilot was 38 at the time and held a valid CPL.

Flying time (hours)				
Previous	24 hours	7 days	90 days	Total
All types	4	14	75	2832
Current type	4	14	75	411

Number of landings on type, previous 90 days: 22.
Training on type was completed on 7 April 2010.
Latest PC was completed on 3 October 2010.

1.5.3 Pilots' duty schedules

The pilots arrived at Arlanda late in the evening of 4 February and began service in the morning of 5 February. Their duty schedules were within permissible limits. The commander, who was taxiing, has stated that he rested as usual during the night.

1.6 The aircraft

1.6.1 Airworthiness and maintenance

The aircraft had a Certificate of Airworthiness and a valid Airworthiness Review Certificate (ARC).

1.6.2 Accessibility and utility of ACAS/TCAS/GPWS/TAWS

Not relevant.

1.7 Meteorological information

According to the SMHI analysis:

Wind W-SW 5-10 knots, visibility 10 km, 2-6/8 with base 7000 ft, temp./dewpoint 1/-1°C, QNH 984 hPa.

[8] PF – Pilot Flying.

According to ATIS[9] braking action on the taxiways was medium to poor. The commander stated that the ground surface was bumpy due to wheel tracks in residual ice.

1.8 Aids to navigation

Navigation at the airport was carried out by means of digital maps.

1.9 Radio communications

Radio communications between the aircraft and the tower were recorded and used after the event. All radio communications were audible. Clearance to the taxiing aircraft contained a non-standardized taxi route that air traffic control may choose to provide as a service.

1.10 Airport data

The airport had operational status under AIP[10]-Sverige/Sweden.

1.11 Flight recorders

In an event of this kind, it is commonplace that CVR[11] and FDR[12] are written over before the investigating authority has received knowledge of the event. In this case it took six days after the occurrence before the information reached SHK. The aircraft operations part of the investigation has therefore been based on interviews with the pilots in combination with recorded radio communications and radar data from air traffic control.

1.12 Location of the incident

1.12.1 Holding position marking

Holding position markings are part of the visual aids at airports to facilitate navigation during taxiing. At Swedish airports, visual aids are regulated by the Swedish Transport Agency regulations in TSFS 2010:133. The following applies to holding position markings according to Chapter 3, Section 45 :

"Holding positions shall be marked at all connections and intersections between taxiways and runways."

The previous regulation for visual aids at airports, BCL-F 2.2, allowed an exception for markings on special holding positions, CAT II and III, i.e. extra holding position/positions in addition to the primary holding position, CAT I. The holding position CAT II or III did not require a marking when a stopbar, controlled by the air traffic services, was installed, and the normal holding position offered sufficient protection. By that time there were a CAT II holding position at the point where holding position Y3 is today. The primary holding position, CAT I, was located about 80 meters closer to the runway on Y3.

[9] ATIS – Air Traffic Information Service – Continuous radio transmission regarding takeoff and landing conditions at the airport.
[10] AIP – Aeronautical Information Publication
[11] CVR – Cockpit Voice Recorder
[12] FDR – Flight Data Recorder

When the airport joined the two holding positions into one, the exception became invalid. As Y3 was reconstructed, with the regulation of that time, a requirement of marking at Y3 existed. The exception was completely made invalid with TSFS 2010:133.

In this case there were no holding position markings at holding position Y3. Taxiway Y3 is an intersection to runway 01L/19R and is part of an area where five possible taxiways meet. In addition to Y3, pilots may also choose Y2 to enter runway 01L/19R from the same area. Taxiway Y goes north and south from the intersection and taxiway D connects from the manoeuvre area where the aircraft in question was parked.

Fig. 4 Remains of previous holding position markings at Y3, 29 June 2011

According to AIP Sweden, neither Y2 nor Y3 has holding position markings, see fig. 8. In this case, there has been holding position markings at Y3, but Swedavia, which is responsible for the operation of the airport, has stated that these were probably worn off by snow removal etc. when runways and taxiways were being brushed clear from precipitation, see fig. 4 and fig. 5. However, there was a marking at level with the RGL, approximately 80 metres further out on Y3, where the painted marks were clear, see fig. 6. This line has been repainted later than the normal holding position marking by Y3.

Fig. 5 Taxi line that the pilots followed. The row of five lamps from left to right is part of a stop bar, 29 June 2011.

Holding position Y3 is wide and despite the angle may be approached by both north and southbound traffic on taxiway Y. The lack of holding position markings at Y3 is a deviation from standard for an airport.

Normally the painting of daylight markings is carried out annually, but there were no daylight markings by Y3 at the holding position. However, there was a daylight marking at the level of the RGL. During an interview one of the pilots said the aircraft had not passed the holding position since the aircraft stopped before the marking on the ground.

Fig. 6 Photograph taken from the holding position at Y3 in level with the stop bar, with the yellow holding position markings at the RGL circled in red, 29 June 2011.

In the summer of 2011 the holding position markings were painted correctly at the holding position at the level of the sign and stop bar at Y3. It has not been possible to present the work order for the painting of Y3 in the summer of 2011

to SHK since it was given orally. At the same time as the holding position markings were painted at Y3, the remaining daylight marking by the RGL was blacked out, see fig. 7.

Fig. 7 Photo at Y3 on 23/08/2011. Photo: Bo Säbb

1.12.2 RGL location

Runway Guard Lights are always in use at Arlanda as a final warning to pilots that the aircraft is on the way onto a runway in use. The regulations regarding the positioning of RGL state that these shall be between the holding position and the edge of the runway. At some airports the RGL are located after the holding position as a single final warning before the runway, and at others they are located at the holding position. At Y3 the RGL were about 80 metres after the holding position.

The commander has stated to Swedavia that he did not see the RGL.

1.12.3 AIP map with markings

An airline rarely uses AIP directly for taxiing, but purchases a service from a company that produces a so-called route manual. It is important that the AIP is correct for the information in the route manual to be accurate in turn. Page AD 2-ESSA-2-5, Markings, in AIP Sweden with taxi markings for runway 01L/19R is expected to contain all markings, but no markings were presented at Y3 (or Y2), see fig. 8.

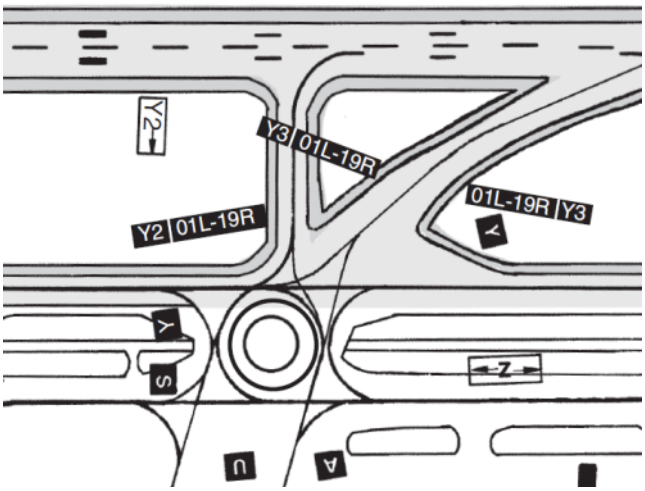

Fig. 8 Part of the AIP Sweden ESSA RWY 01L/19R Markings, received on 29/06/2011. Source: AIP Sverige/Sweden

In connection with the paint job during the summer of 2011, the AIP was up-dated with the correct holding position markings at Y3 (and Y2), see fig. 9.

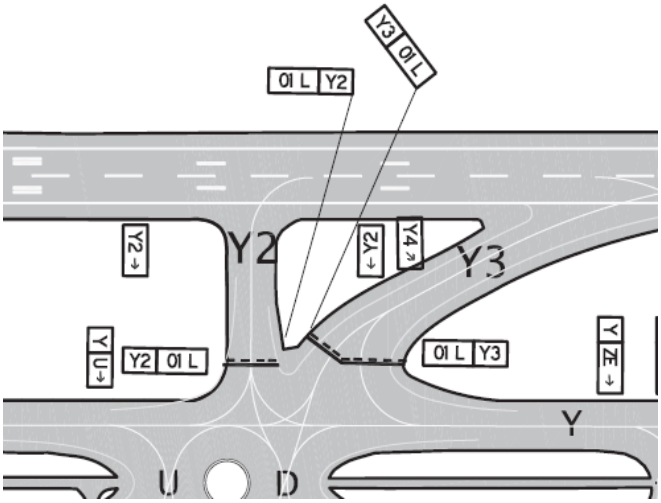

Fig. 9 Part of the AIP Sweden ESSA RWY 01L/19R Markings, received in November 2011. Source: AIP Sverige/Sweden

The area where many taxiways meet has been identified by Arlanda airport as difficult for navigation, and Arlanda has therefore produced an extra chart, Arlanda Hotspot chart, where the holding position was correctly marked.

1.12.4 Stop bars

The aircraft crossed a lit stop bar. SHK has received the airport's log files, which confirm that the stop bar was lit. Apart from a lit stop bar being more difficult to detect during daylight, no other factors were found to indicate why the stop bar was not seen by the pilots. Other pilots operating at Arlanda airport have said to the investigators that the stop bar in question can be difficult to see. However, Arlanda airport has not received any occurrence reports regarding this.

1.12.5 Signs at the holding position

The signs at the holding position were correct.

1.13 Medical information

Nothing has emerged to suggest that the pilots' mental or physical condition was impaired before or during the incident.

1.14 Fire

There was no fire.

1.15 Survival aspects

1.15.1 Rescue measures

By rescue measure is meant those emergency measures referred to in the Act (2003:778) on protection against accidents (LSO) which the government and municipalities shall take in the event of an accident to prevent and limit damage to people, property or the environment. This situation did not call for any rescue measures, so the investigation does not cover that aspect.

1.16 Tests and research

None.

1.17 Company organization and management

1.17a.1 Air Berlin

Air Berlin is a German airline. The company was formed in the 1970s and currently has its headquarters in Berlin.

1.17a.2 LIDO route manual and taxiway chart

All operators use a route manual, which is a manual that contains information about airports, including taxiway charts. The operator uses the Lufthansa route manual, LIDO. The charts are presented digitally on a screen in front of the pilot. The co-pilot, who was looking at the charts, had the taxiway chart for departing aircraft on the screen. The system does not present the aircraft's own position on these charts and therefore they cannot be used as a navigation system.

All the material in a route manual is based on the AIP for each country. This means that, for example, taxiway markings on a chart in the AIP should be reproduced on the same chart in the route manual. The person responsible for quality control of a route manual is the operator.

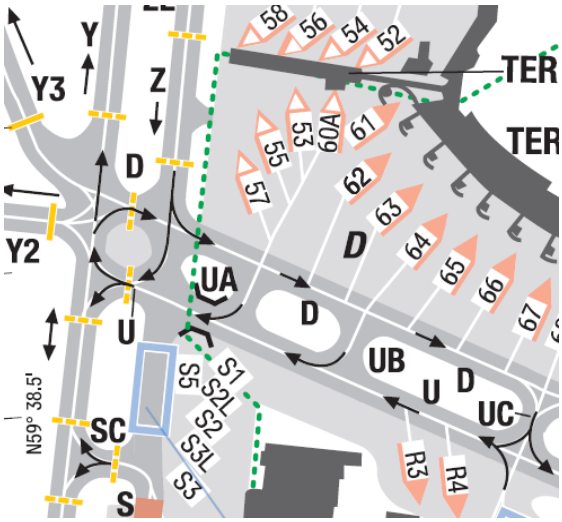

Fig. 10 Excerpt from the pilots' taxiway chart, Lufthansa LIDO, published 01/04/2010

The taxiway chart shows the older holding position (CAT I) at Y3, see fig. 10. However, the stop bar at Y3 is not marked.

1.17b.1 Swedavia Arlanda

History

Arlanda is a state-owned airport. The operator was formerly LFV, but state-owned Swedavia was formed through re-organization and is now responsible for the operation of state-owned Swedish airports.

Operations handbook and the safety management system

In 2009 when the airport decided to implement changes to the holding position system, BCL-F 1.3 regulated safety management systems, but the requirement for operating systems and safety management were very similar to the currently applicable regulations in the same area. The Swedish Transport Agency requires that an airport shall have a working safety management system through the regulation TSFS 2010:122, Transportstyrelsens föreskrifter och allmänna råd om säkerhetsledning av godkänd flygplats [The Swedish Transport Agency's regulations and recommendations on the safety management of an approved airport].

"3 §: At an approved airport there shall be a system for safety management. The system shall be documented in the airport operator's operations manual."

The same regulation further states:

"Before new systems are put into operation, changes to existing systems are implemented, or systems are replaced or removed, a safety evaluation shall be provided to the Swedish Transport Agency. The evaluation shall include a statement that the airport's safety standard is met. "

The operations handbook is available on Swedavia's intranet, and contains procedures and instructions to staff working in different parts of the airport's system, as well as other documents such as work orders and business plans. Most of the documents in the digital operating system are located in a folder structure, arranged after type of activity.

The operations handbook also contains the airport's safety management system, SMS, in accordance with the Swedish Transport Agency's regulations. The safety management system is a separate document, which can be reached from different locations on the intranet. The document can also be found at www.arlanda.net.

The safety management system contains

1. Quality management system
2. Management responsibilities
3. Resource management
4. Measurement, analysis and improvement

Four focus areas have been developed in the Quality management system. These are:

a) Runway and Taxiway Incursion
b) Arlanda Runway Safety Team (RST)
c) Airport lighting and light intensities
d) Wild animal control

For Runway and Taxiway Incursion an instruction describes how occurrences are to be classified to enable statistical follow-ups by the airport. Under Measurement, Analysis and Improvement there is a template of how an internal investigation of an incident shall be carried out. This template has been used, for example, in the airport's own investigation of the incident.

The Quality Management System also explains how document assurance of the AIP is to be carried out. The facility owner or the project manager of a project within the facility has the responsibility of reporting changes to the AIP Forum. During interview with employees that update the AIP, information was unfolded, showing that the system is not functioning fully, which has been unofficially raised within the organization.

The same chapter further describes how the airport reviews internal departments that effect flight safety. The departments are audited each or every fourth year depending on their effect on flight safety. The control and the process of quality audits are performed in accordance with Handbok för revision (Handbook for audits), which can be found at www.arlanda.net.

Periodic maintenance

There is a checklist for the annual painting work in the operating system called "Painting of daylight markings – movement area". The following statement is from that checklist:

"Maintenance of Daylight markings shall be carried out as soon as wear and tear, rubber deposits or other damage leads to the markings not being clear so that they do not pose a risk during taxiing procedures or otherwise lead to a flight safety risk. Improvement of markings shall take place in the spring and autumn. "

The description of the work flow requires that a painting machine be used and that the following tasks be carried out:

1. *Mark the lines that are worn.*
2. *Provide the centre line lights with a cover. Mark the beginning and end.*
3. *Improve the existing marking.*
4. *Cover the wells of the touchdown zone lights. Mark the beginning and end*
5. *Improve the existing marking.*
6. *Repeat this procedure on the apron and TWYs.*

In this description there is no reference to drawings or charts showing which daylight markings are meant.

1.17b.2 Swedavia's investigation of the incident

All occurrences that affect safety at an airport shall be investigated by the airport operator. In this case Swedavia investigated the occurrence and the template in the safety management system was used. In the latest version of the report received by SHK on 17 October 2011, it does not mention that daylight marking at Y3 is missing. However, the investigation states that annual painting was carried out at Y3.

It has emerged during interviews with staff at Swedavia that knowledge about the requirement regarding daylight marking at a holding position with a stop bar was lacking.

1.17b.3 History of Y3

In 2009 a general decision was taken, that all taxiways would be re-built and be provided with one holding position rather than separate CAT I and CAT II holding positions. For Y3 (and Y8) an instruction was produced on 23 July 2009 describing how signs and markings were to be changed to adapt to regu-

lations. The instruction was sent out by e-mail, but it was questioned by field staff who wondered whether the instruction was correct and where the information came from.

SHK has received a memorandum that was drawn up on 24 August 2009, i.e. just over a month after the instruction about Y3 and Y8. The name of the memorandum is, "Adaptation of holding positions to current procedures and local regulations" and includes a description of how the markings and signs were to be adjusted for holding positions with only one place to hold.

No further orders for work to be done at Y3 went out in 2009. From May 2010 there are notes saying that updates of holding positions were to be carried out at Y1 and Y10. In the same notes it was stated that updates were not to be carried out at Y3.

In October 2010 the Swedish Transport Agency issued TSFS 2010:133, Transportstyrelsens föreskrifter och allmänna råd om visuella hjälpmedel för navigering på flygplats [The Swedish Transport Agency's regulations and recommendations on visual aids for navigation at airports].

The occurrence which was the incentive for this investigation occurred on 5 February 2011 and in April 2011 a verbal directive was issued to paint the holding position markings at Y3 and to blacken the line at the old CAT I holding position.

Some time after July 2009, Y3 has been rebuilt and CAT I and CAT II were merged regarding signs to one holding position. When SHK visited and photographed the holding position Y3 in June 2011 it was still unmarked. Later in the summer the holding position became painted and the photographs received by SHK on 24 August 2011 shows that the holding position then met the applicable regulations, see fig. 7 and fig. 11. It has not been possible to find the work order for the paint job in the Swedavia system for work orders, IFS.

Fig. 11 Blacked out lines at the old CAT I holding position.

A new AIP with the correct holding position marking was published in autumn 2011.

1.18 Additional information

1.18.1 Equality issues

The current event has also been examined from a gender equality perspective, i.e. whether there are circumstances suggesting that the current incident or its effects were caused or influenced by the men and women involved not having the same opportunities, rights and obligations in various aspects. No such circumstances, however, were found.

1.18.2 Safety management system (SMS), ICAO[13], and internal auditing

Within the aviation industry, an increasing air safety effort is aimed at ensuring the operators (airlines, airports, air traffic management and others) use an SMS to work proactively with safety issues. In 2009 ICAO published Doc 9859, the Safety Management Manual. The document contains a detailed description of how an SMS is expected to operate.

Although incident reports are frequently used as a source of information, through the use of SMS an organization is expected to detect hazards and risks in other ways, such as by inspections and systematic quality audits of operations.

Doc 9859 also states in appendix 1 to the seventh chapter, that an SMS should include a system description. It suggests that the following areas should be included for an airport:

1.4 Movement area inspection and maintenance
a) Aerodrome manual
b) Inspection forms
c) Maintenance

1.5 Visual aids maintenance
a) Inspections
b) Schedule

1.6 Construction management
a) Control of works
b) Site management

1.7 Apron safety management, including vehicle traffic
a) Traffic signs and markings

The corresponding system description for Arlanda does not appear in the airport's safety management system, and it is not required.

1.19 Special investigation methods

None.

1.20 Actions taken

Arlanda airport has taken the following actions after the occurrence:

- Holding position Y3 has received correct markings and the marking that was at level with the RGL has been blackened.

[13] ICAO – International Civil Aviation Organization

- AIP has been updated with correct markings on page AD 2-ESSA-2-5 (Markings, Taxi guidance system).
- On 23 February 2012 a special visual inspection was performed regarding markings, signs, stopbars and RGL.

2. ANALYSIS

Taxiing aircraft or movement of other vehicles at a major airport is an operation that requires concentration. There is always a risk that a person takes the wrong route, but security barriers can reduce the risk of serious consequences by ensuring that the system is adapted to human capabilities and varying performance.

2.1 Pre-requisites for the pilots

2.1.1 Clearance

To receive another clearance than planned is normal, but is nevertheless a factor which may contribute to some distraction. The airport's standard path for taxiing out is long and complex, but intended to prevent traffic from meeting on the taxiways in order to avoid delays and risks.

A shorter taxiway has benefits for air traffic control and for the airline company. An airline saves fuel and time, which may be critical in order to depart, as well as giving a financial saving. Air traffic control minimizes the time during which an aircraft is in movement on the ground, which leads to smooth and safe traffic management.

In this case there was no shortage of time, but the clearance can still be assumed to have been a mere service. It is reasonable to ask whether a requirement to only provide a standard clearance would have prevented the occurrence. The clearance is one factor in the occurrence, and SHK has weighed the benefits of a requirement that only published and standard clearances should be given against the disadvantages of such a solution. The risk is that such a requirement could lead to air traffic control becoming limited in its ability to function that the probability of traffic flow management not working correctly increases instead. This could then lead to other safety risks as a result of increased traffic volume. Bearing the above in mind, SHK refrains from making any recommendations in this subject.

2.1.2 Taxiway and holding position markings

At the crossing between Y and D where the aircraft was going to turn right, the taxiway line D continues straight ahead. The pilots were expected to turn nearly 90 degrees to the right onto taxiway Y, but continued along the extension of taxiway D onto Y3, which turns about 45 degrees to the right before it connects to runway 01L (see fig. 12).

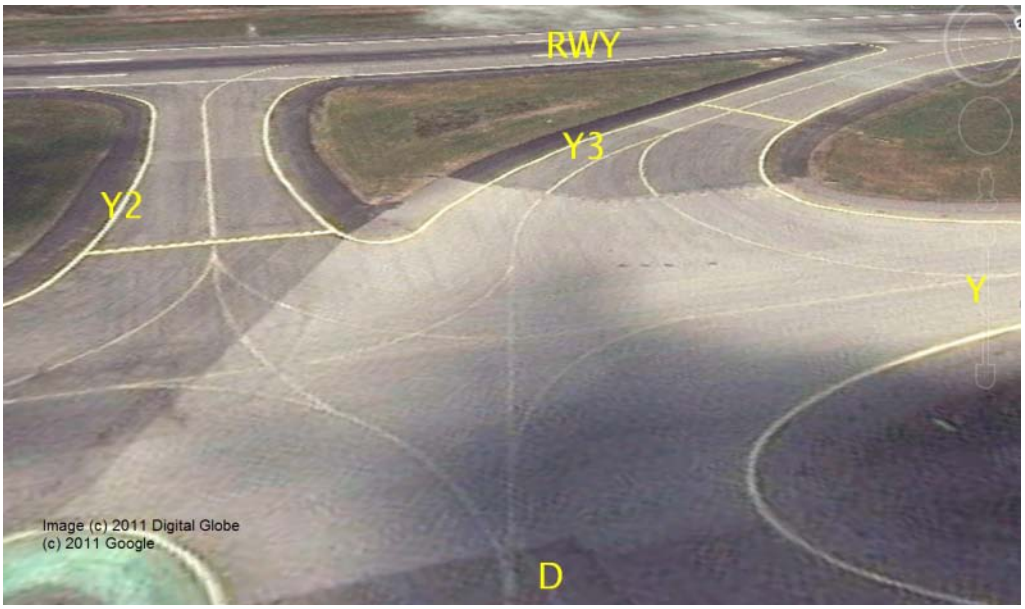

Fig. 12 Side view of the taxiway intersection. Note that this is a satellite image taken from above but viewed from the side, which means that signs and lights are not visible in the picture.

The snow and ice present on the runway cannot be considered to have significantly affected the visibility of the stop bar or the holding position markings. The lack of daylight markings at the holding position at Y3 probably influenced the ability to detect it during the day, particularly as the pilots said that they observed and stopped at the holding position marking further ahead. The lack of daylight marking at the holding position may also have caused the pilot to believe that they were still on taxiway D.

2.1.3 RGL – lights for runway in use

The RGL and the holding position were not at the same place at the holding position in question, which is approved under the regulations. The human eye is drawn to movement and two flashing lights are very easy to detect. It is thus very easy for aircraft to continue taxiing up to the RGL, even though these are separated from the holding position.

The pilots who were expecting to taxi for more than two kilometres before reaching their holding position, has probably not seen the RGL, but it cannot be precluded that the flashing lights subconsciously contributed to the pilots noticing that they were on another position than intended.

2.1.4 Summary of pre-requisites for the pilots

An incident rarely hinges on a single factor. In the occurrence, several small, individually harmless factors contributed to the reduction of information used by the pilots to infer their position. It is also interesting to note that the "extra holding position" at the old CAT I position acted as an additional safety barrier since it was easy for the pilots to detect and they stopped the aircraft in front of it.

2.2 Operations system

2.2.1 The airport's safety management system

In a safety management system, SMS, it is expected that the operator will work proactively with aviation safety issues. Occurrence and deviation reporting is

now a well-known concept in the aviation industry, but an SMS cites more sources than a reporting system in identifying risks, for example quality audits.

In the safety management system for Arlanda, occurrence reporting, auditing and investigations of incidents are described. The lack of reconstruction of holding position Y3 and the painting of the daylight markings at the holding position were never reported as a deviation. The lack of daylight marking at the holding position was clearly noticeable in the summer before the event, but the holding position marking at the old CAT I position was very clear at the time.

SHK has not found that quality checks were carried out for previous paint jobs of the daylight marking at Y3 in order to ensure that the work was done at the right place. The repainting carried out during the summer of 2011 did not result in any quality control or documentation either.

This investigation has only focused on a single holding position at the airport. The history of Y3 has shown major shortcomings in work orders and quality follow-up. It is remarkable that no reviews of the area were made for a long time. There may well be a need for the airport to make a special inspection of all existing visual aids for navigation at the airport.

Since the painting was not ordered through the work order system IFS, this has also made it difficult for the airport's own staff to examine historical changes to Y3. A work order falling outside the work order system and the lack of quality inspection of paint work both constitute shortcomings in compliance with the safety management system.

The safety management system for the airport is contained in a single document under the operational management system on the airport's intranet. This entails a risk that the connection between the system and daily operations is missed. The airport's SMS has major differences from the model for an SMS proposed by ICAO. The question is whether the safety management system is functioning at all levels at the airport and whether everyone who works at the airport feels the involvement and the responsibility that is expected to influence a workplace with an SMS.

The headings listed in section 1.18.2 do not exist in Arlanda's SMS and are not required to be. The structure of the headings means that all areas affected by safety issues at the airport are made visible in the airport's SMS. It is possible that certain quality shortcomings would be possible to detect if the airport's SMS was based on what is proposed by ICAO in Doc 9859.

The areas of focus that Swedavia uses in its safety management system may be an appropriate model in order to focus on areas where risks have been identified. There are other models. SHK considers on the basis of this investigation that the airport may also need to focus on the quality of visual aids for navigation, but leaves it entirely to the airport to find an appropriate method for this.

As a supervisory authority, the Swedish Transport Agency verifies that the airport's safety management system is documented and works. A satisfactory audit was performed at Arlanda airport 7-8 September 2011. The investigation has shown that there may be a need for the Swedish Transport Agency to consider a thorough check into whether the airport's safety management system is actually used in day-to-day operations at the airport.

2.2.2 AIP

The investigation has not been able to explain the lack of holding position markings in the AIP. It has been found that neither the older holding position markings nor the more recent markings appeared in the AIP that was valid in the summer of 2011. Changes to the daytime markings at Y3 have probably not been communicated to those who are responsible for updating the AIP for Arlanda.

3 CONCLUSIONS

3.1 Findings

a) The pilots were qualified to perform the flight.
b) The aircraft's Certificate of Airworthiness had a valid Airworthiness Review Certificate.
c) The taxi clearance given to the pilots differed from the published standard route.
d) A lit stopbar was not seen by the pilots.
e) Holding position marking was missing at Y3.
f) An older holding position marking remained further along Y3.
g) RGL were not co-located with the holding position Y3.
h) The AIP contained incorrect information about holding position markings.
i) The route manual's taxiway chart, which is based on information in the AIP, contained incorrect information about the holding position markings.

3.2 Factors which contributed to the serious incident

- The taxi clearance did not follow the published standard route.
- Holding position marking was missing at Y3.
- An older, no longer valid daylight marking (yellow painted line) in level with the RGL, was perceived as holding position marking for Y3.
- The holding position marking was not consistent with the pilots' taxiway chart, which was based on the AIP.

4. RECOMMENDATIONS

It is recommended that the Swedish Transport Agency should

- in the context of its regulatory work, in particular examine the implementation, operation, and compliance with the system for safety management at Swedish airports. (RL 2012: 07 R1).

- in its ordinary regulatory work, perform a special review of materials relevant for airports in AIP Sverige/Sweden. (RL 2012: 07 R2).

- ensure that Arlanda airport introduces recurrent quality controls of visual aids for navigation at the airport.
(RL 2012: 07 R3).