



Statens haverikommission
Swedish Accident Investigation Board

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Report RL 2003:47e

***Incident involving aircraft LN-RPL
and a tow tractor at Stockholm/
Arlanda airport, AB County, Sweden,
on the 27th of October 2002***

Dnr L-093/02

SHK investigates accidents and incidents with regard to safety. The sole objective of the investigations is the prevention of similar occurrences in the future. It is not the purpose of this activity to apportion blame or liability.

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Translated from the original Swedish by Dennis Lynn Anderson, at the request of the Swedish Accident Investigation Board.

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Statens haverikommission (SHK) Swedish Accident Investigation Board

Postadress/Postal address
P.O. Box 12538
SE-102 29 Stockholm Sweden

Besöksadress/Visitors
Wennerbergsgatan 10
Stockholm

Telefon/Phone
Nat 08-441 38 20
Int +46 8 441 38 20

Fax/Facsimile
Nat 08 441 38 21
Int +46 8 441 38 21

E-mail Internet
info@havkom.se
www.havkom.se

2003-12-15

L-093/02

Swedish Civil Aviation Administration

601 79 NORRKÖPING

Report RL 2003:47e

The Swedish Accident Investigation Board (Statens haverikommission, SHK) has investigated an incident that occurred on the 27th of October 2002 at Stockholm/Arlanda airport, AB County, Sweden, involving an aircraft with registration LN-RPL and a tow tractor.

In accordance with section 14 of The Ordinance on the Investigation of Accidents (1990:717) the Board herewith submits a final report on the investigation.

The Accident Investigation kindly awaits a reply by the 15 of June 2004 concerning how the recommendation issued in the report has been complied with.

Lena Svenaeus

Mats Öfverstedt

Henrik Elinder

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Report finalized 2003-12-15

<i>Aircraft; registration, type</i>	LN-RPL, Boeing 737-800
<i>Class, airworthiness</i>	Normal, valid certificate of airworthiness
<i>Owner/operator</i>	SAS Struktur 1 Handelsbolag/SAS
<i>Date and time</i>	2002-10-27, 16:20 hours during dusk <i>Note:</i> All times in this report refer to Swedish Standard Time (UTC + 1 hour)
<i>Place of occurrence</i>	Stockholm/Arlanda airport, AB County, Sweden (pos. 5939N 01756E; 38 meters above sea level)
<i>Type of flight</i>	Scheduled traffic during taxi
<i>Weather</i>	According to SMHI's analysis at 15:22 hrs: wind 230°/7 knots, good visibility, sky clear, temp./dew point +7/+2 °C, QNH 990 hPa
<i>Persons on board; crew</i>	2 pilots, 4 cabin crew members
<i>passengers</i>	184
<i>Tow tractor</i>	One driver in a tractor (towbarless) of type Goldhofer AST 2 towing an MD-87
<i>Injuries to persons</i>	None
<i>Damage to aircraft</i>	None
<i>Other damage</i>	None
<i>Commander:</i>	
<i>Age, gender, licence, total flying time</i>	36 year old male, D (Swedish), approximately 7,000 hours, of which 529 hours on the type
<i>Flying hours previous 90 days</i>	92 hours, all on the type
<i>Number of landings previous 90 days</i>	76
<i>Co-pilot:</i>	
<i>Age, gender, licence, total flying time</i>	37 year old male, D (Swedish), approximately 5,600 hours, of which approximately 4,000 hours on the type
<i>Flying hours previous 90 days</i>	65 hours, all on the type
<i>Number of landings previous 90 days</i>	51
<i>Tow tractor driver:</i>	43 year old male, tractor towing experience since 1984

The Swedish Accident Investigation Board (SHK) was notified on the 22nd of November 2002 that an incident between an aircraft with registration LN-RPL and a tow tractor had occurred at Stockholm/Arlanda airport, AB County, Sweden, on the 27th of October 2002 at 16:20 hours.

The incident has been investigated by SHK, represented by Lena Sve-naeus, Chairperson, Monica J. Wismar, Chief Investigator Flight Operations until 31 August 2003, thereafter Mats Öfverstedt and Henrik Elinder, Chief Technical Investigator Aviation.

Rickard Jörgensen has assisted SHK as air traffic control expert.

The investigation has been followed by the Swedish Civil Aviation Administration through Kåre Jernling.

Summary

An aircraft of type Boeing 737-800, belonging to SAS, with flight number SK009 landed at Stockholm/Arlanda airport on runway 26. In connection with taxiing in, the pilots misinterpreted the taxi chart in the SAS Route Manual they were using, which caused the aircraft to be taxied onto the wrong side of a "roundabout" situated between taxiways X and Z. Owing to this, the aircraft ended-up on a collision course with a tractor, towing an aircraft of type MD-87 that was transiting the same "roundabout". The tractor driver thought that the Boeing 737 was close to colliding with the tractor. In order to avoid a collision he backed-up the tractor and the attached MD-87 approximately 50–75 meters.

The air traffic controller observed that the aircraft had entered taxiway ZP instead of ZN and pointed this out to the pilots. During the in-taxi the pilots saw the tow tractor with its attached aircraft obliquely left and forward of their aircraft but did not feel that any risk of collision existed.

The investigation has shown that the "roundabout" that the pilots saw between ZN and ZP was not depicted on the taxi chart they utilized. It was also not depicted in the relevant AIP¹. Furthermore it has been ascertained that the design and placement of certain information signs within the taxi system can be misinterpreted.

The incident was caused by the fact that the relevant taxi chart in the Swedish AIP was subject to misinterpretation. Contributory has probably been the unfortunate design of an information sign.

Recommendations

The Swedish Civil Aviation Administration is recommended to revise the present regulations concerning the design of taxi charts in the Swedish AIP and that of information signs, with respect to the risk of misinterpretation. (*RL 2003:47e R1*).

¹ AIP – Aeronautical Information Publication

1 FACTUAL INFORMATION

1.1 History of the flight

An aircraft of type Boeing 737-800, belonging to SAS, with flight number SK009 landed at Stockholm/Arlanda airport on runway 26 after a flight from Luleå/Kallax airport. As the aircraft exited the far end of the runway via the high-speed exit (taxiway XA), the air traffic controller on ground frequency cleared the pilots to taxi to gate number 35 via ZN and taxiway Z (see chart in section 1.10).

The pilots referred to the SAS Route Manual APSI² (taxi chart) as an aid in taxiing. When the aircraft approached Z the pilots aimed at a "roundabout" between taxiways X and Z. With the help of the taxi chart they interpreted the "roundabout" as a depicted ground area immediately to the right of ZN in the direction of travel. They were not of the opinion that the information sign within the "roundabout" depicted anything different. Therefore they chose to proceed around the "roundabout" clockwise in order the subsequently continue taxiing on taxiway Z.

Simultaneously as SK009 landed, there was a tow tractor between Pier A and Pier F, towing an aircraft of type MD-87. The driver of the tractor had been cleared to tow the aircraft to Ramp H with the restriction to stop and hold prior to taxiway X to allow SK009 to taxi in. Normally, towing from Pier A and Pier F to Ramp H takes place via ZP.

When towing operation was approximately at ZP the tractor driver thought that the in-taxiing aircraft was approaching him at high speed and was of the opinion that it would collide with the tractor. In order to avoid a collision, the driver quickly shifted the tractor into reverse and backed-up the tractor and the attached aircraft approximately 50-75 meters.

The air traffic controller observed that the aircraft had entered ZP instead of ZN and pointed this out to the pilots. During the taxi-in the pilots observed the tow tractor with the attached aircraft obliquely left and forward of their aircraft but did not feel that any risk of collision existed. They informed the air traffic controller that the "island" ("roundabout") between ZP and ZN was not depicted on the taxi chart they were using. The incident occurred at position 5939N 01756E; 38 meters above sea level.

1.2 Injuries to persons

	<i>Crew</i>	<i>Passengers</i>	<i>Other</i>	<i>Total</i>
Fatal	–	–	–	–
Serious injuries	–	–	–	–
Minor injuries	–	–	–	–
No injuries	6	184	1	191
Total	6	184	1	191

1.3 Damage to aircraft

None.

1.4 Other damage

None.

² APSI – Aircraft Taxiing and Parking Stands Information

1.5 The crew

1.5.1 Commander

The commander, male, was 36 years old at the time and held a valid D-licence.

Flying hours

<i>Previous</i>	<i>24 hours</i>	<i>90 days</i>	<i>Total</i>
All types	-	92	Approx. 7,000
This type	-	92	529

Number of landings this type previous 90 days: 76.

Flight training on the type completed in October 2001.

Latest PC (proficiency check) carried-out on the 9th of October 2002.

1.5.2 The co-pilot

The co-pilot, male, was 37 years old at the time and held a valid D-licence.

Flying hours

<i>previous</i>	<i>24 hours</i>	<i>90 days</i>	<i>Total</i>
All types	-	65	Approx. 5,600
This type	-	65	Approx. 4,000

Number of landings this type previous 90 days: 51.

Flight training on type completed in January 1992.

Latest PC carried-out on the 11th of October 2002.

1.5.3 The tractor driver

The tractor driver, male, was 42 years old at the time and had worked with towing since 1984.

1.6 The aircraft

The aircraft had a valid certificate of airworthiness.

1.7 Meteorological information

According to SMHI's analysis: wind 230°/7 knots, good visibility, sky clear, temp./dew point +7/+2 °C, QNH 990 hPa.

1.8 Aids to navigation

Not applicable.

1.9 Communications

Below is a transcript of the radio communication between the air traffic controller and the tow tractor driver and pilots on board the in-taxiing aircraft respectively.

Time	From	Information
00:00	T9	Tower, tractor 9.Fox 31 to Hotel.
00:06	GND	Tractor 9, push, call me back.
00:08	T9	Yes, push, call back.
00:41	T9	9 has pushed
00:43	GND	9 proceed to Hotel
00:45	T9	Proceeding to Hotel
01:36	GND	Tractor 9, hold prior to Xray.
01:40	T9	Hold prior to Xray then, tractor 9
01:46	SK009	Ground, Scandinavian 009, good evening [after landing on runway 26]
01:49	GND	Scandinavian 009, good evening, taxi via Zulu November and Zulu for 35
01:54	SK009	Zulu November and Zulu for 35, Scandinavian 009
02:02	GND	And 009 you are number 1.
02:06	SK009	Number 1
02:27	GND	Scandinavian 009 you were told to take Zulu November? towing stop
02:32	SK009	Yes it's ..., the chart (that's a little) funny here, I thought there were two lines there, but there weren't really, but it's all right.
02:39	GND	Tractor 9, continue to Hotel.
02:42	SK009	Yes continue to Hotel, tractor 9, I had to back-up here (you know!)
02:46	GND	Yes, there was a misunderstanding, he had received Zulu November.
02:52	SK009	I almost think that this should be reported, because the chart here shows that Zulu Papa and Zulu November are the same without any island in between.

1.10 Aerodrome information

The layout and equipment of the airport is depicted in the AIP Sweden. Below (next page) is a survey map of the entire airport with the area of the incident circled.

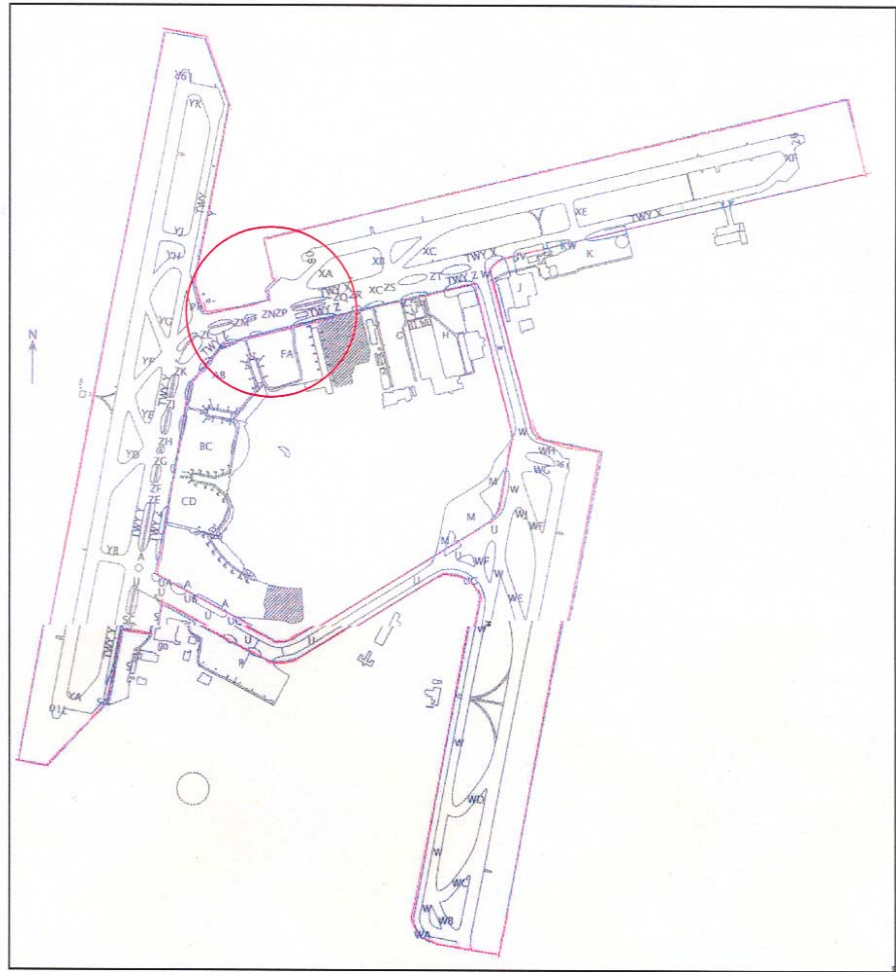
1.11 Flight and voice recorders

1.11.1 Flight recorders (DFDR, QAR, GPS)

The aircraft's DFDR has been transcribed and analyzed. The data registered indicates that the landing and taxiing to the parking gate was normal. When the aircraft vacated the runway and turned onto taxiway XA the ground speed was approximately 31 knots (57 km/h). As the aircraft approached ZP the speed was approximately 22 knots (41 km/h). In connection with the passage of ZP the minimum speed attained was 13 knots (24 km/h).

1.11.2 Cockpit voice recorder (CVR)

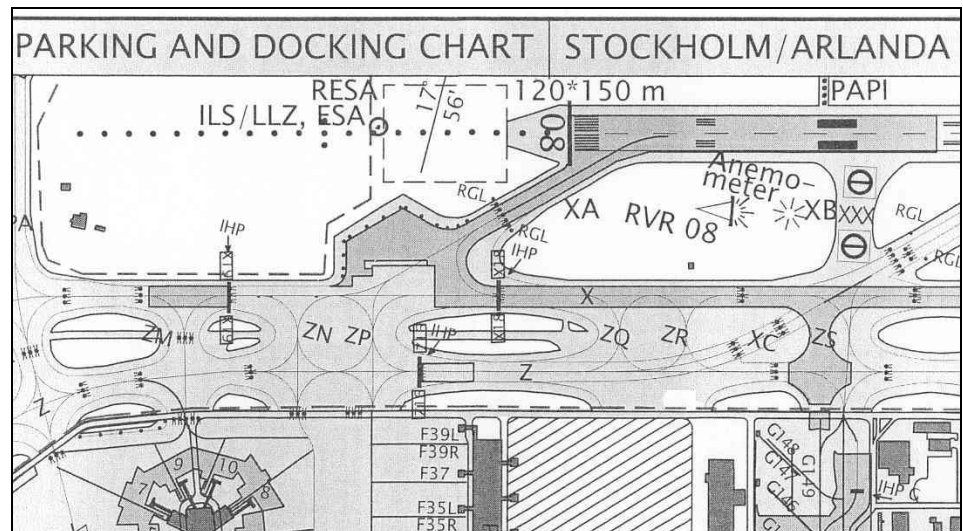
The pilots in the aircraft were of the opinion that no collision incident had taken place. The CVR was not deactivated and the recorded sound in the aircraft was recorded over.



1.12 Incident site

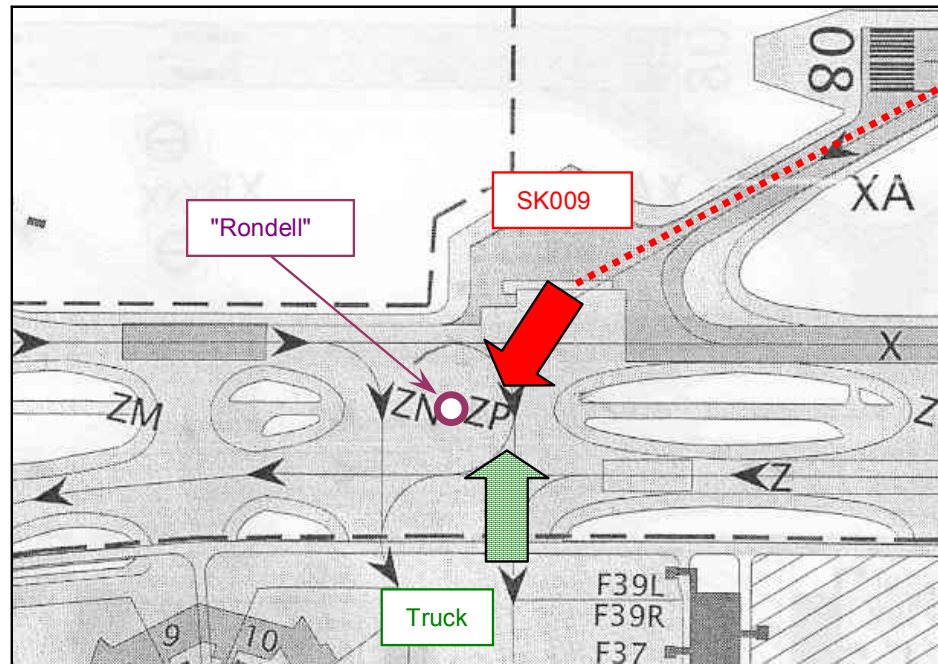
1.12.1 AIP Sweden

Shown below is the area of the airport in question according to the AIP Sweden dated 15 July 2002, which was applicable at the time. All depicted taxiways have centerline lighting. The areas between taxiways X and Z that are depicted on the chart as white fields consist of grass surfaces.



1.12.2 Location of the incident

The incident occurred at ZP. Between ZP and ZN there is a "roundabout", which was marked with colored stakes at the time. The "roundabout" was not depicted in the AIP. The taxiways around the roundabout" have concentrated centerline lighting. According to the airport personnel, the lighting was on at the time on all of the taxiways in the area. On the chart depicted below from the AIP/ARRIVAL, the "roundabout" has been drawn in as a circle. The approximate positions of the aircraft and the tow tractor at the time of the incident have been marked with arrows.



1.12.3 The "roundabout"

The "roundabout" consists of a circle with a diameter of approximately 20 meters that is painted onto the asphalt surface between ZN and ZP. There are three illuminated information signs within the circle. One of these, with the appearance depicted below, is facing north and is readable from XA. This is a combination type sign, where the letters "ZN" are supposed to show that the aircraft is on a specific taxiway as viewed from the left-hand pilot position (pilot in command) and the symbol "<- Z ->" is intended to show directions to taxiway Z, behind the sign.



The photo below shows the "roundabout", as seen from XA, a few months after the incident.



1.13 Medical information

No medical investigation has been performed.

1.14 Fire

There was no fire.

1.15 Survival aspects

Not applicable.

1.16 Tests and research

None.

1.17 Organizational and management information

1.17.1 *Stockholm/Arlanda airport*

Stockholm/Arlanda airport is owned and operated by the Civil Aviation Administration. Flight operational activities at the airport are subject to the approval of the Swedish Aviation Safety Authority. Other activities shall be conducted according to valid regulations. The operational responsibility for safety work and safety equipment at the airport is delegated under the office of Airport Safety Management.

Described in the handbook "SAFETY SYSTEMS ANALYSIS FOR STOCKHOLM-ARLANDA AIRPORT" is the process and the methods that are to be utilized at the airport for consultation with the Aviation Safety Authority and for the approval of the basis that is to be used for the application of operational approval for new construction or equipment, which have undergone such modifications that earlier approval documents are affected.

Concerning the basis for the AIP Sweden, there is an elaborate process account that describes the routines and the conditions of responsibility that

are to guarantee that the AIP is compiled in accordance with valid national and international regulations.

1.17.2 *Scandinavian Airlines Systems (SAS)*

The airline SAS conducts national and international scheduled passenger flights. The company headquarters are in Stockholm. Operations Management is also stationed in Stockholm. The SAS Route Manual is compiled by SAS Flight Support AB (now the European Aeronautical Group) and is based on the published AIP.

1.18 **Additional information**

1.18.1 *Taxiways*

Regulations concerning the design and marking of taxiways are stated in the Swedish Rules of Civil Aviation (BCL)-F 2.1 and 2.2.

Regarding centerline lights, generally these are to be installed so that they provide continuous guidance from the centerline of the runway to a position on the ramp where the aircraft initiates its parking maneuver.

Regarding guidance systems for ground movements, visual aids (daylight markings, lighting, and signs) are to be designed so that they contribute to the prevention of collisions between aircraft, vehicles and fixed objects within the trafficked area.

Within the valid regulations, SHK has not found any special instructions concerning the marking of and information in the AIP of the type of "roundabout" that was involved in the incident here under investigation.

1.18.2 *Taxiing at airports*

As a general rule, during all taxi operations, aircraft shall follow the centerline of the taxiways and the centerline lighting according to published airport charts. Daylight markings, lights and information signs shall be utilized as a visual aid for navigation and determination of position.

1.18.3 *Information signs*

Information signs shall, according to BCL-F 2.2 paragraph 32, if possible be placed on the left-hand side of the taxiway. SHK has not found any specific regulations as to how letters and symbols on combination signs shall be placed with respect to each other in order to minimize the risk of misinterpretation.

1.18.4 *Project 2002 Pier F, Ramp FA*

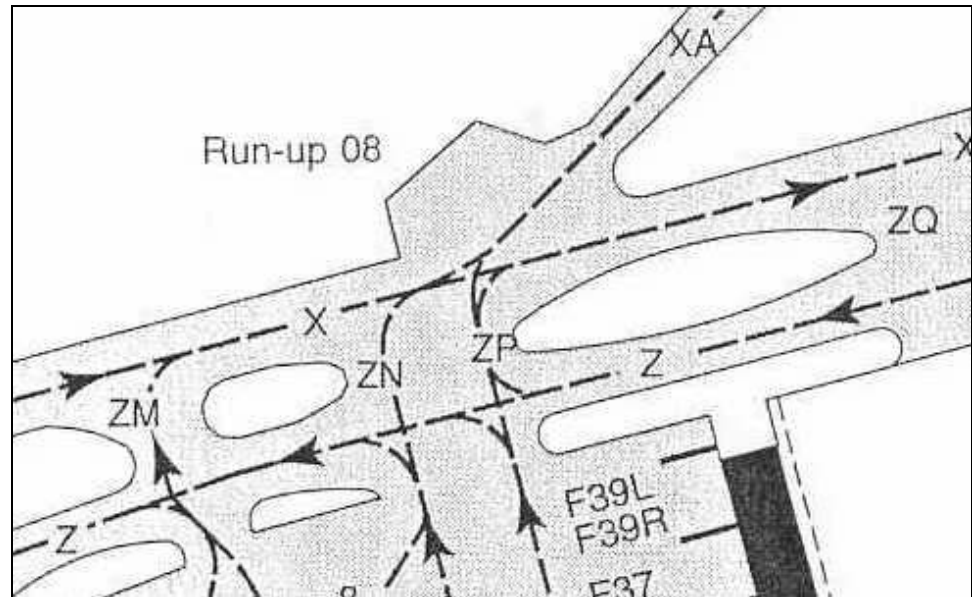
Prior to the new air traffic control tower and the new terminal (Pier F) being put into operation, a taxiway system was constructed in front of Pier A and around Pier F. The previous taxiway ZP was extended to the west and taxiway ZN was added. According to the airport regulations, as a part of this reconstruction, a so-called safety validation was accomplished concerning the reconstruction. The safety validation, which is substantiated, showed that the taxiway system fulfilled the valid requirements according to BCL-F.

1.18.5 *Applicable chart in SAS Route Manual*

On the taxi chart in the SAS Route Manual, which the pilots used during the in taxiing, the "roundabout" between ZN and ZP was not depicted (see below). The chart was based on the AIP dated 15 July 2002. According to re-

ports from the Swedish Civil Aviation Administration, the AIP chart had been unchanged since the 23rd of December 2001.

The pilots have stated that they believed that the area between ZN and ZP consisted of an open surface without any "island" in between. Subsequent to the incident the "roundabout" (island) has been drawn-in in both the AIP and the SAS Route Manual.



SAS Route Manual

1.18.6 ICAO Annex 15

In Annex 15 of the International Civil Aviation Organization (ICAO) there are certain regulations in Chapter 4 concerning the contents and design of airport charts. Principles are also stated here about how changes to such charts shall be accomplished. Considerable freedom is provided for national formulation. Thus there are no specific demands about how a roundabout of the type presented in this investigation shall be depicted on the charts.

2 ANALYSIS

2.1 The incident

From a flight safety viewpoint the incident was serious. After landing the SAS aircraft was cleared to taxi to the parking gate via ZN and taxiway Z. The pilots understood the clearance however they chose the wrong route, whereby the aircraft taxied instead via ZP. This resulted in the aircraft being placed on a collision course with the tow tractor that was holding at ZP. Even though the pilots in the aircraft never experienced any risk of collision, the tractor driver's description of the sequence of events would seem to indicate that a collision might have taken place if he had not backed-up the tractor with its attached aircraft and cleared ZP for the in-taxiing aircraft.

It is a well-known fact that taxiing at large airports is, in certain cases, difficult. Often the taxiway systems are complicated and variations exist with respect to the design of visual aids for taxi operations. The air traffic controllers' routines and technical aids for control of traffic on the ground also vary. Darkness, limited visibility and high traffic density also contribute to making taxi operations demanding.

Access to updated airport charts containing correctly depicted taxiways and various types of visual aids is still the basis upon which all taxi operations rest. Taxiing shall be conducted along the centerline and the centerline lighting of the taxiways in order to assure lateral clearance from fixed objects. Daylight markings, lights and signs are to be utilized in order to acquire a general overview of the immediate vicinity and to determine the position of the aircraft.

In addition to these aids it is natural that pilots consciously or subconsciously use other visual references in the immediate area. Such references at Stockholm/Arlanda airport can be the grass surfaces between the taxiways, which are depicted in the AIP as white fields.

At the time of the incident the pilots were using these visual references, depicted on the taxi chart they were using, in order to follow the taxi route they had been cleared for. As mentioned above, all of the grass areas between taxiways X and Z were depicted on the chart they were using, but not the "roundabout" between ZN and ZP.

Taking into consideration how the "roundabout" appeared from the viewpoint of the pilots (see chart and picture in 1.13.2-3), it is understandable that they mistook it for the grass area that is situated immediately to the right of ZN in the direction of travel.

Even the combination sign that the pilots observed within the "roundabout" lends itself to misinterpretation.



It is true that the sign is situated to the left of ZN, according to the instructions in BCL-F 2.2. However, because the letters "ZN" on the sign itself are placed to the left of the symbol " $\leftarrow Z \rightarrow$ ", it may be very likely to interpret the sign as indicating that ZN lies to the left of the sign and also on the left side of the "roundabout", which in this case is erroneous. Even the symbol " $\leftarrow Z \rightarrow$ " can be considered to be ambiguous, as taxi way Z, which lies behind the sign is a "one-way" taxiway to the right from the viewpoint of the observer.

In the opinion of SHK, it is these ambiguities that taken together caused the pilots to misinterpret the chart and taxi the wrong way.

2.2 The taxiway system

SHK has not found any indication that the reconstruction of the taxiway system at ZN and ZP, including updating of the AIP was not accomplished according to the applicable BCL and safety requirements.

However, there does not seem to be any requirement within the applicable regulations concerning the marking of and information in the AIP about the special areas or "roundabouts" that are situated between the taxiways. Also these areas are not cleared of snow and therefore during the winter months may be mistaken for the clearly marked and depicted grass areas of the taxi system.

Furthermore, SHK has not found any instructions that describe how letters and symbols on combination signs shall be placed with respect to each other in order that they shall not be misinterpreted.

As recently as August 2003 SHK published a report (RL 2003:32) wherein it is established that, among other things, the taxiway system at Stockholm/Arlanda airport is complex and that there is a risk that operational mistakes may be made. In the recommendation, *RL 2003:32 R1*, the Swedish Civil Aviation Administration recommended to "perform an unbi-

ased review of the airport's taxi system with regard to measures which can be taken to diminish the risk of operational mistakes".

The incident here under investigation supports that recommendation, but also reveals the need to perform an unbiased review of the current regulations concerning the design of taxi charts and information signs with respect to the risk of misinterpretation.

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 tow tractor driver was qualified to perform the towing.
- d) The pilots misinterpreted the taxi chart and taxied the wrong way.
- e) The "roundabout" that the pilots saw between ZN and ZP was not depicted in the AIP or on the taxi chart that they utilized.
- f) The design and placement of certain information signs can be misinterpreted.
- g) The reconstruction of the taxiway system at ZN and ZP was completed according to applicable regulations.

3.2 Causes of the incident

The incident was caused by the fact that the relevant taxi chart in the Swedish AIP was subject to misinterpretation. Contributory has probably been the unfortunate design of an information sign.

4 RECOMMENDATIONS

The Swedish Civil Aviation Administration is recommended to revise the present regulations concerning the design of taxi charts in the Swedish AIP and that of information signs, with respect to the risk of misinterpretation (*RL 2003:47e R1*).