Statens haverikommission
Swedish Accident Investigation Board

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Report RL 2008:06e

Collision between aircraft B-HIH and a tow vehicle at Stockholm/Arlanda airport, AB county, Sweden on 25 June 2007

Case L-12/07

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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Statens haverikommission
Swedish Accident Investigation Board

2008-10-06 Case L-12/07

The Swedish Civil Aviation Authority
SE-601 73 NORRKÖPING, Sweden

Report RL 2008:06e

The Swedish Accident Investigation Board (Statens haverikommission, SHK) has investigated an aircraft accident that occurred on 25 June 2007 at Stockholm/Arlanda airport, A/B county, involving an aircraft registered B-BIH.

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

The Board will be grateful to receive, by 1 April 2009 at the latest, particulars of how the recommendations included in this report are being followed up.

Göran Rosvall Stefan Christensen

Appendices

Report RL 2008:06e

Case L-12/07
Report finalised 2008-09-11

Aircraft; registration and type	B-HIH, Boeing 747-267B
Class/airworthiness	Normal, valid Certificate of Airworthiness
Registered owner/Operator	Cathay Pacific Airways
Time of occurrence	25 June 2007, at 03:33 hours, in daylight Note: All times are given in Swedish daylight saving time (UTC + 2 hours)
Place	Stockholm/Arlanda airport, AB county, (position 59° 38.3′ N, 017° 55.9′ E, 30 m above sea level)
Type of flight	Commercial air transport (cargo)
Weather	According to SMHI's analysis: wind variable 3 knots, visibility 10 km, scattered clouds with base at 2000 feet, broken clouds at 9000 feet, temp./dewpoint 12/11 °C, QNH 1006 hPa
Persons on board:	
crew members	3
Passengers	2 (off-duty crew)
Injuries to persons	None
Damage to aircraft	Substantially damaged
Other damage	Damage to tow vehicle
Commander:	
Sex, age, licence	Male, 58 years, ATPL
Total flying time	19050 hours, of which 8947 hours on type
Flying hours previous 90 days	95 hours, all on type
Number of landings previous 90 days	10
Co-pilot:	
Sex, age, licence	Male, 33 years, ATPL
Total flying time	5913.4 hours, of which 1552 hours on type
Flying hours previous 90 days	128 hours, all on type
Number of landings previous 90 days	11
Flight engineer:	
Sex, age, licence	Male, 54 years, Flight Engineer's Licence
Total flying time	16401 hours, of which 5296 hours on type
Flying hours previous 90 days	97.5 hours, all on type
Number of landings previous 90 days:	No information
Cabin crew members	Not applicable

The Swedish Accident Investigation Board (SHK) was notified on 25 June 2007 that an aircraft with registration B-BIH was involved in an accident at 03:33 hours on that day at Stockholm/Arlanda airport, AB county.

The accident was investigated by SHK represented by Göran Rosvall, Chairman and Stefan Christensen, Investigator in Charge.

The investigation was followed by Ulrika Svensson, Swedish Civil Aviation Authority.

Summary

The aircraft should depart from Stockholm/Arlanda on a cargoflight to Dubai. The crew had flown to Stockholm as passengers earlier in the evening. The aircraft, a Boeing 747, was parked on the southern cargo ramp area. Due to delayed flights into Stockholm, the crew arrived late to the aircraft. Further delay came up due to a misunderstanding concerning the time for closure of the main runway at Arlanda, which caused operational problems regarding planning of the flight.

A number of companies were contracted for services in connection with the flight, i.e. ground handling, technical service, operational information and cargo handling.

As the aircraft was parked with the nose in at the gate, intention was to perform a push back with a push back vehicle connected to the nose wheel at the aircraft. One technician was present for assistance in connection with engine start and push back. Two people were present from the ground handling company, one truck driver under training and his supervisor. After signal from the pilots the push back was commenced in a right turn at the same time as the engines were started. After termination of the push back the parking brakes were set and the technician told the pilots that the push back vehicle should be disconnected and removed.

The pilots read the checklist after engine start. The check list did not contain any point concerning “clear signal”, i.e. a sign in form of thumb up from the technician, implying that all is clear for the aircraft to start taxiing under own power. About 45 seconds after the message from the technician that the push back vehicle should be disconnected, the aircraft started to taxi without any “clear signal”. The vehicle had been disconnected from the nose wheel and backed a bit so that the driver could change to the forward driving position. The vehicle was not backed far enough to get into the pilot’s field of vision.

The driver and the technician had to run in order to be safe, and the left inner engine on the aircraft hit the push back vehicle. At the collision the engine was substantially damaged, when the upper corner on the vehicle teared up the cowling and caused damage to engine systems. The aircraft taxied a short distance before the damaged engine stopped. At the time of the accident – which occurred 03:33 in the morning – the pilots had been awake 18-20 hours.

The aircraft leaked jetfuel from the damaged engine. Alarm to the Fire and Rescue service was not made until 57 minutes after the accident.

The accident was caused by inadequate checklists for the pilots in respect of checking that an all clear signal had been received. A probable contribution was that stress and fatigue factors limited the concentration abilities of the pilots.

Recommendations

- It is recommended that the Swedish Civil Aviation Authority ensures that the fire safety regulations for Stockholm/Arlanda and other relevant Swedish airports are revised so that collisions involving aircraft are assigned a sufficiently high risk assessment. *(RL 2008:06 R1).*

- It is recommended that the Swedish Civil Aviation Authority ensures that the operating manuals for air traffic control at Stockholm/Arlanda and other relevant Swedish airports are revised so that collisions at the airport involving aircraft are a criterion for raising the alarm with the rescue services. *(RL 2008:06 R2).*

1 FACTUAL INFORMATION

1.1 History of the accident

1.1.1 Conditions

The planned flight was to be a regular cargo flight from Stockholm/Arlanda airport to Dubai. This service is operated several days a week with a cargo version of a Boeing 747-200 aircraft. The crew, consisting of the commander (F/C), first officer (F/O) and a flight engineer (F/E), were based in Germany and England and had arrived at Arlanda as passengers before the planned flight. The airline had a representative at Arlanda and had also engaged various service companies at the airport, for the operational handling of flights, and also for loading and unloading cargo.

Apart from the cargo it was planned that two further aircrew would accompany the flight. They had completed their duties and would be carried as passengers. The F/O for this particular flight, who had arrived in Stockholm earlier than his crew colleagues, prepared planning for the flight with assistance from the F/O who would accompany the flight as a passenger.

The F/C and F/E arrived on a delayed flight from London to Arlanda. They were met by the company's local representative in Stockholm, who assisted with the briefing and planning for the flight, and also later with the transport out to the aircraft.

1.1.2 Take off preparations and engine starting

The aircraft was parked at stand R9 in the southern freight area. Due to the delays, the loading and other preparations had been completed by the time the flight crew came out to the aircraft. However a further delay occurred due to incorrect operational information. Runway 01L/19R, which is the longest runway at Arlanda, was scheduled to be closed for work on the runway at 06:00 on the particular morning of this take-off. In the operational information that was given to the flight crew, and which also acted as a basis for the FMS[1] programming and performance calculations, it was incorrectly stated that the runway would already be closed at the planned time of departure. The consequence would be that take-off would have to be planned for one of the shorter runways, with possible performance limitations and/or load reduction as a result. The problem was however resolved after the flight crew had made contact with the company's operations department in Hong Kong by telephone.

The flight crew began the Before start checklist and also made contact via the aircraft interphone with an SAS dispatcher on the ground below the aircraft. The aircraft was parked nose in to the parking stand, so a tow vehicle (see section 1.6.1) with a tow bar was attached to the nosewheel of the aircraft to push it out backwards to the intended position on the taxiway. This procedure is called "pushback". After the engines have been started and the pushback completed, the aircraft must be braked and the vehicle tow bar disconnected. After the vehicle has been driven away and the area around the aircraft is clear, the dispatcher is to give the pilots a "thumbs up" all clear signal, which means that everything is ready for the aircraft to taxi under its own power.

[1] FMS: Flight Management System, flight and navigational planning computer.

On this occasion there were - beside the dispatcher - two people present for the pushback procedure, a driver under training and his supervisor. All ground personnel stayed outside the eight metres radius risk area from the jet engines which were running.

1.1.3 Pushback and taxiing out

Pushback commenced after engine number four (the outer right hand engine) had been started. The flight deck crew had agreed that the F/O would be the Pilot Flying (PF) for this particular flight. On the B 747 this means that the PF – after completion of the push back - also controls and manoeuvres the aircraft on the ground. During pushback, which was performed as a wide right turn backwards, the other engines were started, the last one when the aircraft and tow vehicle had stopped after pushback was completed. The driver of the tow vehicle disconnected the tow bar and reversed the vehicle a short distance in order to change to the driving position at the other end of the vehicle. The crew read out the "after start checklist" and performed the items in the list. The dispatcher stood to one side of the nose on the left side of the aircraft to wait for the tow vehicle to be finally driven away before he should give the thumbs up signal to the pilots. The pushback driver's supervisor monitored the procedure while standing some distance from the left side of the aircraft.

When the driver of the pushback tow vehicle sat down in the forward position to start the vehicle engine and drive it away, he heard the sound of the aircraft engines get louder, and could see from the corner of his eye that the aircraft was starting to move towards him. He then abandoned starting the vehicle and ran away from it. The dispatcher also started to run when the aircraft began to taxi. Together with the supervisor, the dispatcher tried to attract the attention of the aircraft commander by waving as the aircraft rapidly approached the parked tow vehicle, but all they could see was the elbow and part of the head of the aircraft commander. As far as they could see, his attention was fixed on the direction of the turn, i.e. to the right.

During this right turn, the aircraft collided with the stationary tow vehicle. The outer side of engine number two (left inner) struck the front section of the tow vehicle, causing damage to, among other things, the engine nacelle and parts of the engine fuel system. The flight crew heard a light thud and a "juddering" during the turn, and thought that this was due to the nose wheel skidding on the ground during such a tight turn.

1.1.4 The engine failure

The pilots started taxiing towards the runway, but after about 30 seconds the flight engineer saw that the number two engine was not indicating normal readings and informed the commander: "There is something wrong with number two engine". Soon afterwards the engine stopped. The commander ordered the checklist for engine failure and also reported to air traffic control that there was a problem and they wanted to taxi back to the parking area.

During taxiing fuel was leaking from the damaged engine. The trail of leaked jet fuel on the ramp area and taxiway was later measured as extending for about 150 metres. It was only while taxiing back in and

parking the aircraft that the flight crew became aware that there had been an accident and that one of the aircraft engines was damaged. After the accident, the civil aviation personnel informed the special airport group, who commenced cleaning up the area. 57 minutes after the accident the civil aviation personnel also informed the airport fire and rescue unit, since the engine was still leaking fuel. Both the dispatcher and the pushback personnel were in a minor state of shock after this event.

The accident occurred at position 59° 38.3′ N, 017° 55.9′ E, 30 m above sea level.

1.1.5 Overview of the events

The following overview was prepared on the basis of extracts from the Cockpit Voice Recorder, audio tape recordings of the communication with air traffic control and interviews with those involved.

Text in blue indicates events in the cockpit.

Text in brown indicates events on the ground.

All timing referred to below is in respect of 3 a.m., Swedish daylight saving time.

Time	Event
31:41	Pushback completed and the tow vehicle stopped. The flight crew applied the parking brake as requested by the dispatcher outside the aircraft.
31:45	The tow bar was disconnected and the pushback tow vehicle was reversed: • According to the tow vehicle driver: “About 20-30 metres”. • According to the supervisor: “About 10-20 metres”. • According to the dispatcher: “About 5-10 metres”. (The maximum distance that the tow vehicle could be reversed from its stopped position without being visible from the cockpit is about 9 metres)
31:45-32:45	The dispatcher stands out of sight of the pilots, under the aircraft nose, in order to prevent misunderstanding.
31:57	All four aircraft engines have started and the commander says to the dispatcher: “Clear to disconnect.”
32:00	Response from the dispatcher: “We disconnect, have a nice flight.”
Approx. 32:05	The tow vehicle driver stops his engine and walks to the other end of the vehicle.
Approx. 32:10	The dispatcher removes the steering locking pin from the aircraft nose wheel and waits for the tow vehicle to be finally driven away.
32:11	Commander: “After start checklist please.”
32:12-32:30	The pilots perform the actions in accordance with the checklist.
32:31	Commander: “Your controls.”
32:34	First Officer: “My controls.”
32:35	Commander: “Cathay 064 taxi.” (VHF to the control tower)
32:43	First Officer: “Clear right.”
32:44	Commander: “Clear left.”
32:45	The aircraft begins to taxi without having received the “clear” signal from the ground. The time from applying the aircraft

	parking brake until it started to taxi was estimated at: • According to the tow vehicle driver: "Less than one minute." • According to the supervisor: "About two or three minutes." • According to the dispatcher: "A couple of minutes." (The actual time, according to the CVR: 1 minute and 4 seconds)
Approx. 32:45-32:55	The tow vehicle driver prepares to start the vehicle engine but is surprised by the increasing sound from the aircraft engines and indirectly notices that the aircraft is starting to move towards him.
Approx. 32:55	The tow vehicle driver runs away from the tow vehicle. The dispatcher runs away from the aircraft and tries, together with the supervisor, to attract the commander's attention by waving.
Approx. 33:00	It is not possible to contact the aircraft commander. The ground personnel can only see his elbow at the side window and glimpse his head. His attention was fixed on the direction of the turn (to the right).
Approx. 33:10	The outside of engine number two (left inner) collides with the pushback tow vehicle during the right turn.
Approx. 33:10	The engine is seriously damaged. The fuel pumps, fuel lines and control units are damaged. Fuel leaks out from the engine. The flight crew do not notice the collision, only a slight "juddering".
Approx. 33:10-33:45	The engine continues to run briefly on the remaining fuel in the lines, but stops after about 30 seconds. The extent of the fuel leakage is measured as being about 150 metres.
33:45	Flight engineer: "There is something wrong with number two engine."
34:55	Commander: "Engine failure checklist number two."
35:19	Commander: "Cathay 064 we'd like to return to the gate."
35:25	The aircraft begins to taxi back to the parking area.
35:54	First Officer: "I thought the bumps was just me turning in acute angle."
38:36	The aircraft returns to the parking area again and the remaining three engines are shut down.

1.2 Injuries to persons

1.2.1 Personnel information

	Crew members	Passengers	Others	Total
Fatal	–	–	–	–
Serious	–	–	–	–
Minor	–	–	–	–
None	3	2	–	5
Total	3	2	–	5

1.2.2 Ground personnel

	Aircraft handling technician (dispatcher)	Ground handler	Others	Total
Fatal	–	–	–	–
Serious	–	–	–	–
Minor (shock)	1	2	–	3
None	-	-	–	-
Total	1	2	–	3

1.3 Damage to aircraft

Considerable damage to the left inner engine. The engine cowling and internal systems, including fuel lines, fuel pump and fuel control unit which suffered severe damage.

1.4 Other damage

Damage to the pushback tow vehicle. Minor damage to the vehicle's driving position and body.

1.5 Personnel information

1.5.1 The commander

The commander, male, was 58 years old at the time and had a valid Hong Kong Airline Transport Pilot Licence.

Flying hours			
previous	24 hours	90 days	Total
All types	0	95.4	19050.0
This type	0	95.4	8947.1

Number of landings this type previous 90 days: 10.
Flight training on type carried out on 23 March 2004.
Latest PC (Proficiency Check) carried out on 5 April 2007 on Boeing 747.

1.5.2 Co-pilot

The co-pilot, male, was 33 years old at the time and had a valid Hong Kong Airline Transport Pilot Licence.

Flying hours			
previous	24 hours	90 days	Total
All types	0	128.1	5913.4
This type	0	128.1	1552.0

Number of landings this type previous 90 days: 11.
Flight training on type carried out on 22 June 2004.
Latest PC (Proficiency Check) carried out on 15 October 2006 on Boeing 747.

1.5.3 Flight engineer

The flight engineer, male, was 54 years old at the time and had a valid Flight Engineer's Licence.

Flying hours			
previous	24 hours	90 days	Total
All types	0	97.5	16401.0
This type	0	97.5	5296.0

1.5.4 Cabin crew members

Not applicable

1.5.5 The crew duty schedule

The commander was on the third day of his current duty roster when the accident occurred. The current duty had been preceded by a rest period of 24 hours. According to his interview he had rested normally on the night before the accident and had not had any difficulty sleeping. The commander began this part of his duty by flying passively from London to

Stockholm. At the time of the accident, 3:30 am, he had been awake for about 20 hours.

The first officer was on the third day of his current duty roster which had begun with passive transport from London to Munich on day 1. On the next day he had flown passively from Munich to Stockholm, to begin active duty with this particular flight. He had rested normally, but had to "force himself" to sleep. There was no precise information concerning the time he was awake before the accident, but this can be estimated as being at least 18 hours.

The flight engineer was on the third day of his current duty roster when the accident occurred. The current duty had been preceded by a rest period of 24 hours. According to his interview he had rested normally on the night before the accident and rested during the day before his duty began. The flight engineer had flown passively, together with the aircraft commander, from London to Stockholm late in the evening before the accident. There was no precise information concerning the length of time he was awake before the accident.

1.5.6 Interviews with the crew

SHK interviewed the three active flight crew members on the day after the accident. None of the flight crew members stated on being interviewed that they felt "abnormally" tired and all said that the planned duty was a relatively typical example of a duty roster for the flight crews in the company. None of the flight crew reported that they felt any difficulties due to the variations in duty time, which sometimes included time zone effects, and thought that one could to some extent get used to working in this way.

The F/C and F/O stated that they did not experience the engine start and pushback as being any other than normal. Communication with the dispatcher on the ground was experienced as standard routine. The F/C stated that he thought the wait for the clear signal was "long" (the time from the dispatcher saying "brakes on" until the F/C requested permission to taxi was, according to the CVR, 59 seconds) and, when no signal came from the dispatcher, he assumed that it was clear to start taxiing. He said that he based his decision partly on earlier experience at Arlanda, when he found that the dispatcher "had gone" after engine start, so that taxiing had to begin without an all clear signal. The F/O related that many F/Cs followed the routine of saying to the dispatcher after engine starting was completed: "See you on the left – show me the pin". This particular F/C did not however use this phrase.

When the F/C and F/O had checked that both sides were clear, taxiing began, initially straight towards the tow vehicle that was parked in front of the aircraft. Since the taxiway link UE out to taxiway U was so close, a right turn was commenced more or less immediately on taxiing. The F/C said that his attention was directed to the right, both because the F/O was to taxi the aircraft, and because the direction of movement of the aircraft was to the right. Neither of the pilots saw the ground personnel who stood waving at the left side of the aircraft.

During the turn the crew felt a light thud and “juddering”, and thought that this was from the nose wheel caused by such a tight turn. It was not until they began to taxi in and park that they realized there had been a collision between the aircraft and the vehicle. From his position the F/E had had a relatively restricted view and was not aware of everything that happened, except for the observations that took place when engine number two stopped.

1.6 The aircraft

Fig 1. B 747 cargo version

1.6.1. General

The aircraft				
Manufacturer	Boeing			
Type	B 747 – 267B			
Serial number	23120			
Year of manufacture	1984			
Flight mass	Max. authorised take-off/landing mass 377843/285762 kg			
Centre of mass	32/734			
Total flying time	104526 hours			
Number of cycles	21538			
Flying hours since latest C check	589 hours			
Fuel loaded before event	82700 kg Jet A1			
Engines				
Manufacture	Rolls-Royce			
Model	RB211-524D4			
Number of engines	4			
Engines	*No. 1*	*No. 2*	*No. 3*	*No. 4*
Total operating time, hrs	105052	90845	87082	91804

Operating time since overhaul	4596	4115	11705	6352
Cycles since overhaul	1021	911	2605	1406

The aircraft had a valid Certificate of Airworthiness.

1.6.2 *Normal checklist*

The checklist followed by the pilots after engine start contains items that must be checked, performed or verified before the aircraft begins taxiing. The items in the normal checklist are brief and do not contain any descriptions or operating instructions beyond the text in the list. Detailed descriptions of each step and other instructions are contained in the expanded checklist, which is not used by the pilots during normal operations.

The following is an extract from the company's normal checklist for the B747 after engine starting:

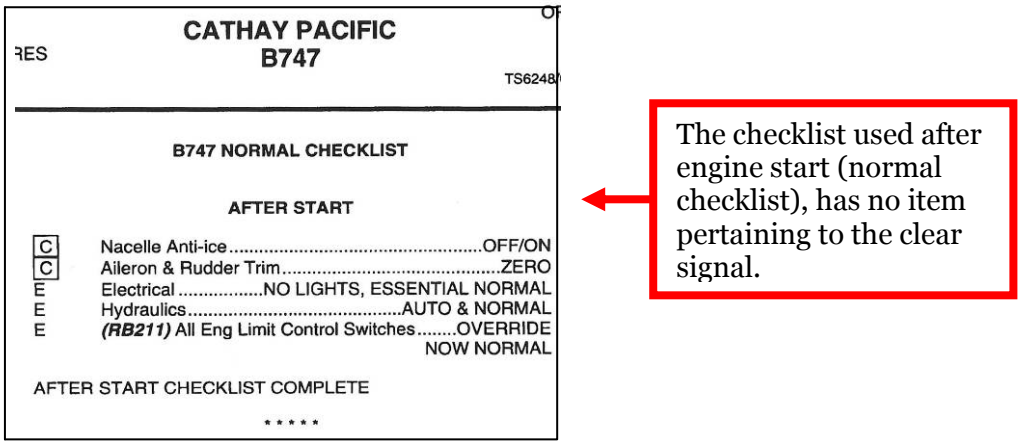


Fig 2. Extract from the normal checklist

1.6.3 *Expanded checklist*

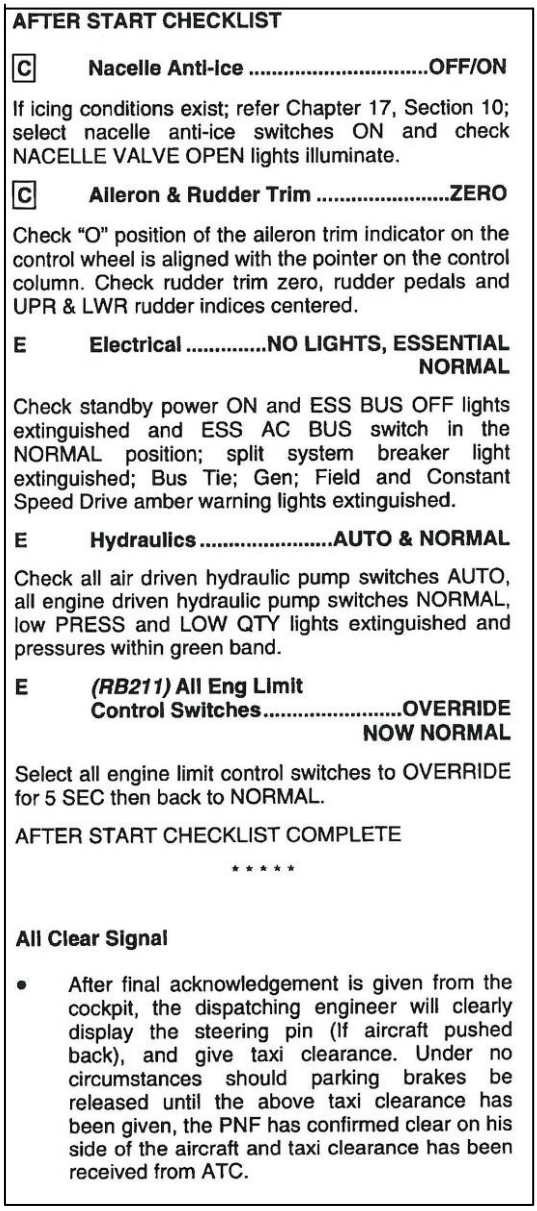
All the items that are in the normal checklist are also contained in the expanded checklist, with detailed descriptions of the procedures that must be carried out in connection with each particular item. The expanded checklist also contains sections of an informative nature that are not included as mandatory items in the checklist.

The expanded checklist is part of the documentation that is kept on board, but is not used by the crew during normal operations. The crew is expected to be currently familiar with the content and changes in the expanded checklist, by means of training and continuation training on the particular aircraft type.

The section in the expanded checklist dealing with the clear signal is an example of information to the crew that does not at the same time form a mandatory item in the normal checklist. Items of an informative nature are expected to be performed/checked by crew in the same way as an item that

is on the checklist, with the difference that they are not brought up as specific items, but must be performed as learned and memorised actions.

The following is an extract from the company's expanded checklist for the B747 after engine starting:



AFTER START CHECKLIST

C **Nacelle Anti-Ice .....OFF/ON**

If icing conditions exist; refer Chapter 17, Section 10; select nacelle anti-ice switches ON and check NACELLE VALVE OPEN lights illuminate.

C **Aileron & Rudder Trim .....ZERO**

Check "O" position of the aileron trim indicator on the control wheel is aligned with the pointer on the control column. Check rudder trim zero, rudder pedals and UPR & LWR rudder indices centered.

E **Electrical .....NO LIGHTS, ESSENTIAL NORMAL**

Check standby power ON and ESS BUS OFF lights extinguished and ESS AC BUS switch in the NORMAL position; split system breaker light extinguished; Bus Tie; Gen; Field and Constant Speed Drive amber warning lights extinguished.

E **Hydraulics .....AUTO & NORMAL**

Check all air driven hydraulic pump switches AUTO, all engine driven hydraulic pump switches NORMAL, low PRESS and LOW QTY lights extinguished and pressures within green band.

E ***(RB211)* All Eng Limit Control Switches.....OVERRIDE NOW NORMAL**

Select all engine limit control switches to OVERRIDE for 5 SEC then back to NORMAL.

AFTER START CHECKLIST COMPLETE

* * * * *

All Clear Signal

- After final acknowledgement is given from the cockpit, the dispatching engineer will clearly display the steering pin (If aircraft pushed back), and give taxi clearance. Under no circumstances should parking brakes be released until the above taxi clearance has been given, the PNF has confirmed clear on his side of the aircraft and taxi clearance has been received from ATC.

The expanded checklist contains more detailed information concerning actions for each item on the checklist. There is no item concerning the clear signal.

Supplement to the expanded checklist concerning all clear. This item is not included in the checklist, but is informative.

Fig 3. Extract from the expanded checklist

1.6.3 Damage to the pushback tow vehicle

Fig 4. The vehicle

The vehicle	
Manufacturer	Schopf 356
Engine	Deutz F12L, 413 303H
Weight	43,000 kg
Length	7.60 m
Width	2.98 m
Height	1.60 m (2.50 m with elevated driver's cab)

The tow vehicle is one of the larger model used at Arlanda airport and is used during the pushback of larger aircraft. The vehicle has driver's positions at both ends, of which one is adjustable in height. The particular tow bar is specially intended for the pushback/towing of the B747 and has a length of 3.3 metres.

Fig. 5. The tow bar

During pushback with a Schopf 356 it is the practice to reverse the vehicle somewhat and then to go round and change driver position. In order to do this the engine must be switched off, the key removed and the handbrake applied. The reason for changing to the other driving position is that after the change the driver has a better view and the vehicle, which does not have a rear view mirror, does not need to be reversed.
One consequence of the change of driving position is that the driver thereafter manoeuvres the vehicle forwards, while having his back towards the parked aircraft.

1.7 Meteorological information

According to the SMHI (Swedish Meteorological and Hydrological Institute) analysis:
Wind variable 3 knots, visibility 10 km, scattered clouds with base at 2000 feet, broken clouds at 9000 feet, temp./dewpoint 12/11 °C, QNH 1006 hPa.

1.8 Aids to navigation

Not applicable.

1.9 Communications

Communication between the aircraft and air traffic control and certain other places was recorded and obtained. Selected parts of the communication have been printed out and integrated with the printout of the Cockpit Voice Recorder (CVR) in Appendix 1.

1.10 Aerodrome information

1.10.1 Stockholm/Arlanda airport

At the time of the accident, 03:33, the airport status was in accordance with AIP[2] Sweden. At 06:00 one of the runways, 01L/19R was to be closed for repair and maintenance work. Information concerning this had been promulgated in the form of a NOTAM[3]. Runway 01L/19R is the longest runway at Arlanda and is often required for large aircraft to be able to take off with full load.

The aircraft was parked at stand R9 in the southern freight area. The Swedish Civil Aviation Authority is responsible for the Airport Regulations (AR), in which regulations for all movements on the ground within the airport area are grouped. The AR contains instructions concerning pushback procedures at the various terminals and aircraft parking areas. The instructions in the AR are generalised and mainly contain instructions as to the directions and to which positions aircraft shall be backed out.

[2] AIP: Aeronautical information publication – aeronautical information of a long term nature.
[3] NOTAM: Notice To Airmen - aeronautical information of a short-term nature.

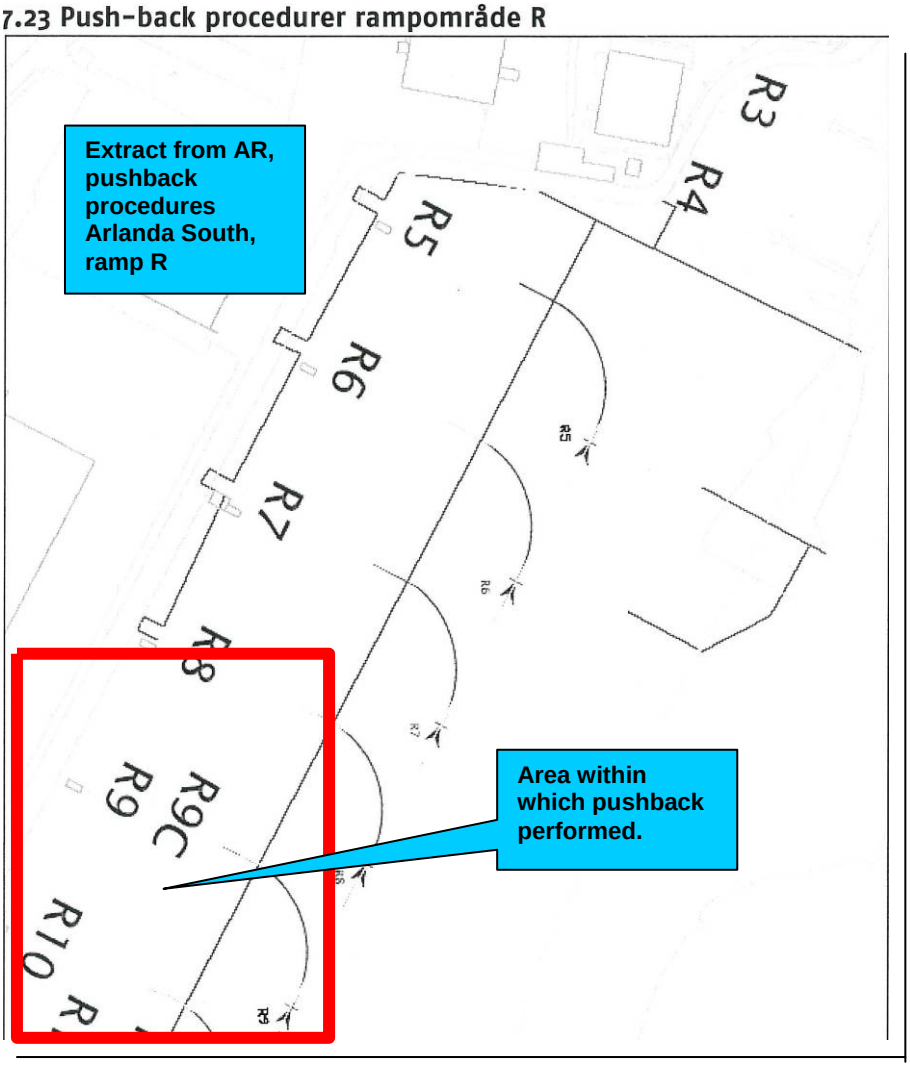


Fig 6. Extract from the AR
(Illustration heading: 7.23 Pushback procedures for ramp area R)

1.10.2 Aircraft operator's representation and service companies at the airport

For the cargo operations the company had agreements with several agencies and bodies at Arlanda airport. These agencies provide various services that are necessary for operations to be carried out in an efficient and safe manner. Below follows information concerning some of the bodies that were involved in the handling of the company's freight business:

Cathay Pacific's local representative

The company had its own representative at Arlanda, with the task of managing all internal and external contacts and to arrange co-ordination between the contracted bodies. The representative also had the task of supervising the handling associated with freight aircraft arrivals and departures at Arlanda.

Cubic Air Cargo handling agent

This agent was responsible for cargo handling and operational handling, such as weather information, NOTAMs, loading instructions and mass and balance calculations. The agent is normally in contact with the flight crew during their time on the ground in order to resolve possible operational problems and other issues.

SAS Ground Service (SGS) ground handling

The handling company that is responsible for the necessary auxiliary services while the aircraft is on the ground, such as ground electrical power, external stairs, de-icing, pushback, etc. At the time of the accident the pushback tow vehicle was being driven by a driver under training. He had long experience of pushback operations, but not in respect of the tow vehicle being used and this type of aircraft. His work was therefore being monitored by a supervisor. Both of these personnel were trained and authorised to perform these particular duties.

SAS Technical Service (STS) technical handling

A company that provides various types of technical services at the airport. In this particular case the airline had procured "start-up service", involving technical assistance in the form of a flight technician in connection with engine start and pushback. This service is normally carried out by technicians within a special department of STS, the "foreign airline group", concentrating on services for foreign companies. Due to the time of day there was no technician available from this group, so an ordinary flight technician from STS was called in. He was trained and authorised to perform the task, although he had not handled the B747 previously.

1.11 Flight recorders and voice recorders

The aircraft was equipped with a flight data recorder and a cockpit voice recorder.

1.11.1 Digital Flight Data Recorder (DFDR)[4]

The aircraft was equipped with a Lockheed type flight data recorder. The printout was not examined by SHK. However the operating company had on its own initiative read the content of the aircraft's QAR[5], and from this provided certain data to SHK. The content supported this report's description of the sequence of events. In order to confirm the time of the aircraft taxiing, however, one of the results from the QAR read-out has been inserted in the CVR transcript in Appendix 1.

1.11.2 Cockpit Voice Recorder (CVR)[6]

The aircraft was equipped with a Honeywell type cockpit voice recorder. At the request of the SHK the recorder was taken out of the aircraft and sent for analysis to the AAIB (Air Accidents Investigation Branch) in Great Britain. The detailed track on the CVR with high quality has a recording time of 30 minutes but had been overwritten. However a recording was also made on the "combination track" that has a recording time of two hours. This track does not separate the pilot locations and is of somewhat lower quality. The results were printed out by a laboratory in Sweden that had been engaged by SHK. Parts of the transcript are given in this report and the entire transcript, linked on a timing basis with certain other communications, is provided in Appendix 1.

1.11.3 Other recordings

The high definition airport surface detection radar system had recorded images of the event. These were inspected by SHK but could not provide the investigation with any new facts. There were surveillance cameras installed

[4] DFDR: Digital Flight Data Recorder
[5] QAR: Quick Access Recorder, flight data recorder with fewer parameters.
[6] CVR: Cockpit Voice Recorder, unit for recording sounds from the cockpit.

in the area but at the time of the accident these were not directed towards that specific location.

1.12 Accident site

1.12.1 Accident site

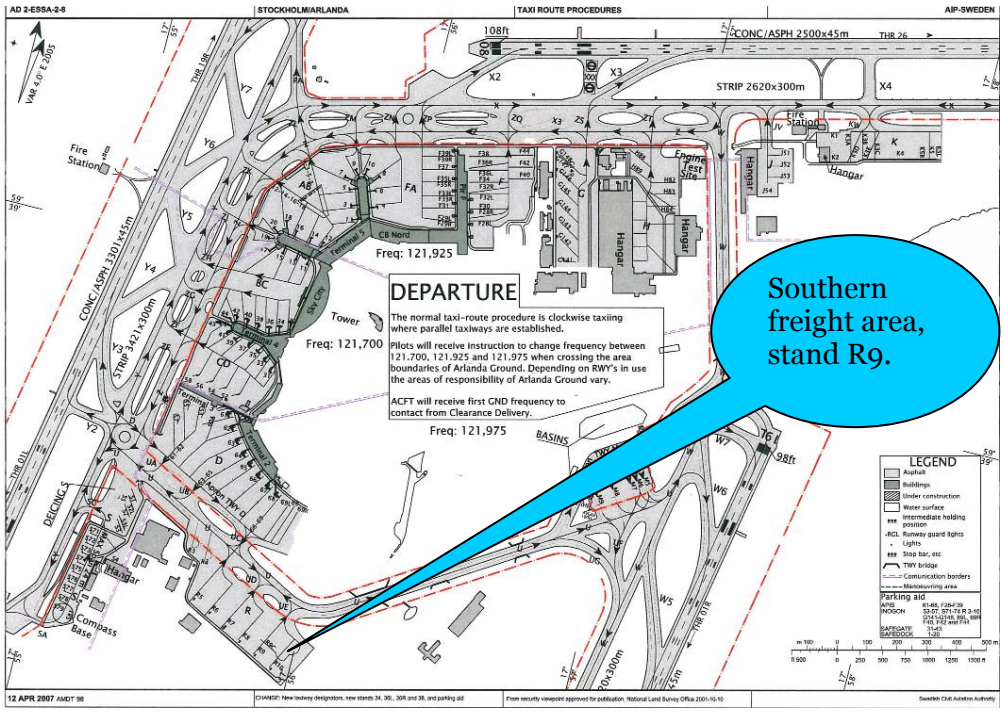


Fig 7. Location of R9 in the southern freight area, at Arlanda airport.

1.12.2 The aircraft after the collision

Fig 8. The aircraft parked after the accident.

Fig. 9. The damaged engine.

1.12.3 The tow vehicle after the collision

Fig. 10. The damaged tow vehicle

The vehicle suffered damage at its rear where the outside of the aircraft engine struck it. The steering wheel was deformed and the upper right of the vehicle rear showed traces of the collision in the form of damage to the body, indicating that this corner had penetrated 20-30 centimetres into the aircraft engine nacelle. The lower part of the vehicle mostly showed paint scraping and scratches. The front part of the vehicle showed no visible signs of the collision.

1.13 Medical information

Apart from the lengths of periods when the pilots were awake, nothing has been found to indicate physical or psychological impairment before the flight.

1.13.1 Fatigue factors - general

Research and accident investigations have shown that fatigue is an important and preventable cause of accidents in the transport sector[7] Fatigue due to loss of sleep and circadian disruption can significantly impair human capabilities in respect of judgement and decision-making, attention and reaction time, alertness, memory and mood. Such factors can in turn increase the risk of fatigue-related accidents and incidents, and reduce the operational safety margins.

Working continuously with time zone shifts and a disturbed circadian rhythms can mean that certain habits in respect of the consequences of this can be acquired. Commonly this means however that it is easier to be aware that one will become fatigued, not that through experience the fatigue can be worked away.

The specific physiological factors that can cause fatigue are:

- circadian rhythms (the time of day),
- continuous hours of wakefulness,
- sleep (acute and cumulative sleep debt),
- sleep disorders.

The factors are additive, so that fatigue at any moment is determined by the situation regarding the biological daily rhythm, the length of time spent awake and the amount of sleep obtained.

1.13.2 Circadian rhythms

The biological circadian clock not only controls such physiological activities as body temperature and digestion, but also performance, alertness and mood. The circadian clock is programmed for a minimum level of activity at around 3 to 5 a.m. This is a period of low physiological and functional activity. Performance reductions can occur in a larger window, from about midnight until 6 in the morning.

In this particular case the accident occurred at 03:33 in the morning.

1.13.3 Continuous hours of wakefulness

The length of time someone spends awake is another physiological factor that can affect performance and alertness. The length of time spent awake is equal to the number of hours one has been continuously awake. The relevant physiological factor is how long one has been awake, and not so much how long one has been working during this period without sleep. In general performance and alertness can be maintained for twelve hours of being continuously awake (however the type of work being done is very important). After 16-17 hours of continuously being awake, there can be a significant reduction in performance and alertness.

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[7] See, for example: Rosekind M.R. et al Examining Fatigue Factors in Accident Investigations: Analysis of Guantanamo Bay Aviation Accident, Alertness Solutions, NASA Ames Research Center, National Transportation Safety Board.

In this particular case both the commander and first officer had experienced periods without sleep lasting or exceeding 18 hours, which coincided with the time of day when the body is programmed to sleep.

1.13.4 Sleep

The adult person's sleep requirement varies between six and ten hours, but an average adult needs about seven or eight hours in order to perform optimally and be alert. Sleep loss is defined by the total amount of sleep during a 24 hour period compared with the amount of sleep one normally needs. Studies have shown that two hours of sleep loss can result in reduced performance and alertness.
Sleep loss that builds up over several days results in a cumulative sleep debt.

In this particular case, no acute or cumulative sleep debt has been noted. In the case of the first officer, the daily rest had been normal, although it was stated that there was some difficulty in falling asleep.

1.13.5 Sleep disorders

In addition to the length of a sleep period, its quality is important. The quality can be affected by the surrounding conditions, the time of day and various kinds of sleep disorders. Disrupted circadian rhythms, due to time zone shifts (jet lag) can increase fatigue.

In this particular case none of the flight crew said that they suffered from jet lag, since they had been rested after the previous duty sector and were in a normal circadian rhythm. No other sleep disorders were mentioned during the interviews.

1.14 Fire

Fire did not occur in connection with the accident. During the approximately 30 seconds after the collision that the engine continued to run, jet fuel did however leak out in an area that was very close to the hot engine exhaust. A number of electrical wires were present inside the damaged engine nacelle.

1.15 Survival aspects

1.15.1 General

The Emergency Locator Transmitter (ELT) of type Honeywell RESCU 406 was not activated in the accident.

1.15.2 Actions by the rescue services

The accident did not result in any personal injury, apart from the fact that the three ground personnel suffered from mild shock. The fire and rescue services were not called out in connection with the accident. 57 minutes after the accident, however, the airport fire and rescue unit was called out, since the engine was still leaking fuel.

1.15.3 Risk factors

The safety rules applicable to personnel working in the vicinity of jet aircraft on the ground with engines running state that the distance from the engine air intakes must not be less than eight metres. The B737 is an exception, where this distance has to reduced somewhat while connecting

and disconnecting ground power. The principal reason for this safety distance is that there is a great risk of being drawn into a running jet engine, with a minimal chance of survival. In this particular case, apart from the risk of being drawn in, there was also the risk of being struck by one of the 18 wheels of the aircraft.

1.16 Tests and research

1.16.1 The field of vision from the cockpit

SHK has examined the size of the area that is visible from the cockpit for that particular individual aircraft.

The investigation was carried out with an observer in the left-hand pilot's seat with correct "eyeball"[8] adjustment set. The purpose of the investigation was to determine how large the area on the ground, in front of and beneath the nose of the aircraft, that was hidden from the pilots during ground operations. The investigation did not take into account any possible changes that could occur with different weights of the aircraft.

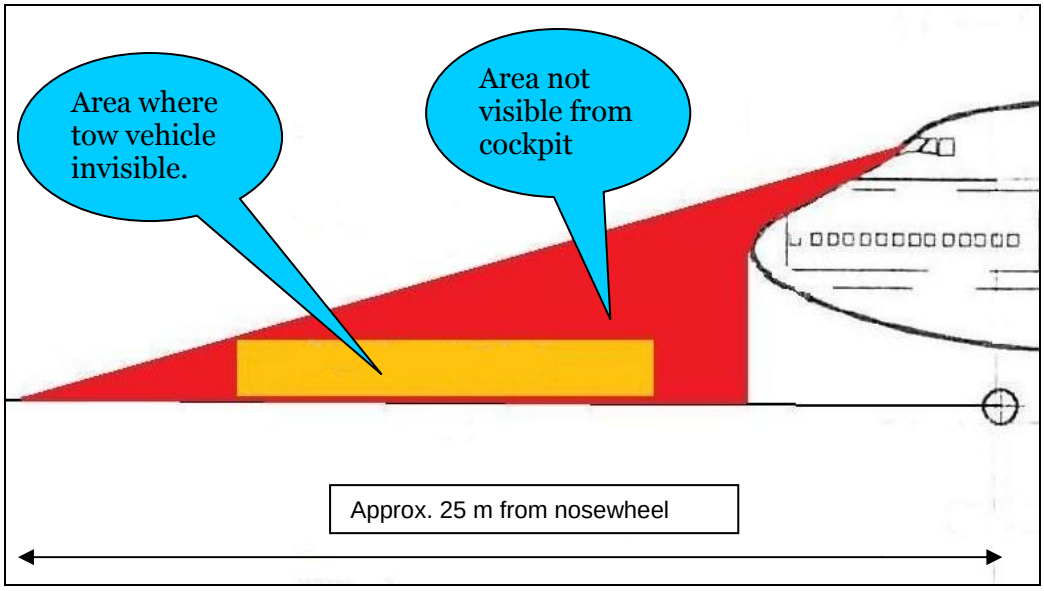


Fig 11. Sketch of the visual field

Figure 11 above shows the area in front of and beneath the nose of the aircraft that was hidden from the pilots. The measured distance on the ground was about 25 metres, using the nose wheel as a datum. With the configuration of the Schopf 356 at the time of the accident, without the driver's cab elevated, the far end of the tow vehicle superstructure would have been visible to the pilots at a distance of about 20 metres from the nose wheel.

1.16.2 Check on technical services during flight departures

The commander stated that on a previous occasion in connection with engine start and departure from Arlanda he noticed that after engine start the dispatcher "had disappeared". This would have implyed that after a long wait the aircraft commenced taxiing, without receiving an all clear signal in the form of a thumbs up from the dispatcher.

[8] Eyeball: Adjustment index for pilot seat location in height and distance from the controls. Used so that the pilot's eyes shall always have the same reference frame, e.g. during approach and landing in fog.

On request from SHK the commander's work schedule was checked, with the purpose of clarifying on which dates he had departed from Arlanda during the year preceding the accident.

The dates that were found were compared with the STS work schedule, with the intention of interviewing the technicians who were on duty during the departures with this particular commander. The interviews revealed straight away that none of the technicians on duty had experienced anything abnormal during the departures in question. All claimed that standard procedures had been followed and that they had given the all clear signal in the form of a thumbs up before taxi was commenced.

1.16.3 Police intervention associated with the accident

About 34 minutes after the accident the ADO (Airport Duty Officer) telephoned the Arlanda airport duty police officer and reported the accident. A car with a police patrol was sent to the accident site. On arrival the police went up to the aircraft cockpit and took statements from the flight crew. The police also requested breath tests from the commander with the intention of determining whether there was any trace of alcohol on the breath. The regulations in accordance with Swedish legislation in respect of permitted limit values of alcohol in the blood in connection with control of a vehicle also apply within restricted areas such as Arlanda airport. In the case of air transport there are special regulations, controlled by both international requirements and aviation law.

The test performed on the commander was negative, i.e. there was no measurable result in respect of alcohol on his breath. No similar tests were carried out on the tow vehicle driver or any other of the personnel present at the accident site.
During the interview carried out by SHK after the accident it was revealed that the instructions for the police in the case of a vehicle collision or similar event were that testing for alcohol should be carried out on both parties involved.

1.17 Organisational and management information

1.17.1 General – the airline

The airline is based in Hong Kong, where the operational and technical management also are located. Apart from commercial transport of passengers the company carries out cargo operations on a "world-wide" basis, i.e. not only flying from the local area but performing cargo flights on several continents. Most of the crews are based in Hong Kong, but some are based in other places, such as Germany and Great Britain.

1.17.2 Departure routine – pushback procedure

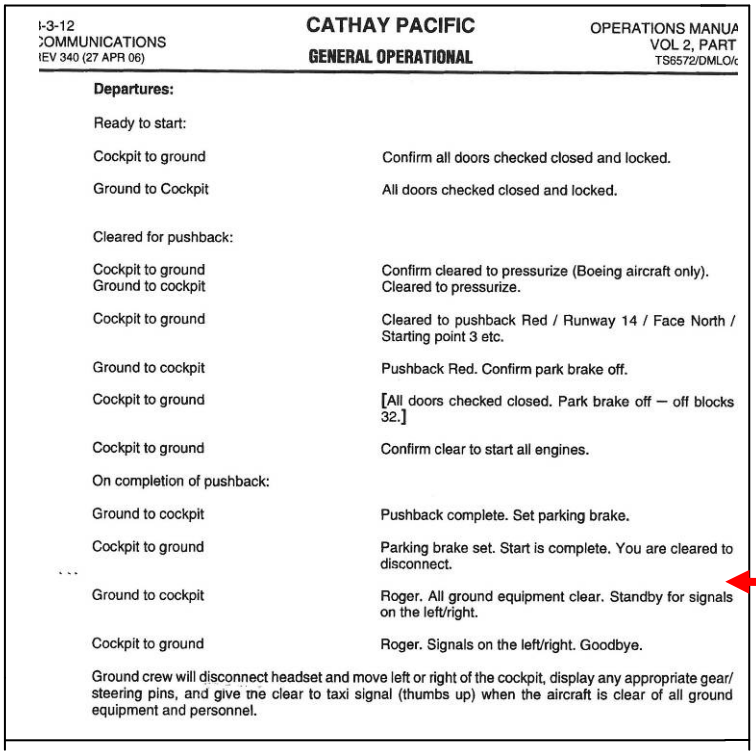
During the type of pushback procedure being considered here, a tow bar is connected to a specially provided securing point on the aircraft nosewheel. During this procedure a special steering locking pin is inserted, to permit free movement of the nosewheel without it being influenced by the otherwise activated hydraulic steering system. The tow vehicle driver starts reversing the aircraft under the supervision of a technician/pushback supervisor (dispatcher). The manoeuvre may be performed straight back or as a turn. The final position is determined by the conditions and instructions for the airport, but generally the aircraft shall from that point be able to commence taxi under its own power.

At the completion of pushback the dispatcher reports to the pilots that the aircraft parking brake should be applied so that the tow bar can be disconnected. After completing the pushback the dispatcher normally shows the steering locking pin to the crew, at the same time giving the thumbs up signal. The engines may be started before, during or after pushback, depending on local regulations and the type of aircraft.
When the commander gets the thumbs up signal, this means that all ground equipment has been disconnected and that the dispatcher sees no obstacles for taxi. The final responsibility for ensuring that all is clear for taxiing lies however always with the commander.

1.17.3 Departure routine – company manuals

In the company's Operations Manual – OM there are routines described for management and communication between the cockpit crew and ground personnel. Fig. 12 shows a description of how the dispatcher is to report to the pilots that all is clear and that they must await the (clear) signal at the left or right side. This is then to be acknowledged by the pilots.

In one of the company's technical manuals (Engineering – Organisation & Maintenance Procedures Manual, fig. 13) the communication is also described. The text in this manual differs from that in the OM. Information concerning the steering locking pin has been added and the acknowledgement from the pilots has been reduced to "Roger".



1-3-12
COMMUNICATIONS
REV 340 (27 APR 06)

CATHAY PACIFIC
GENERAL OPERATIONAL

OPERATIONS MANUA
VOL 2, PART
TS6572/DMLO/c

Departures:

Ready to start:

Cockpit to ground	Confirm all doors checked closed and locked.
Ground to Cockpit	All doors checked closed and locked.

Cleared for pushback:

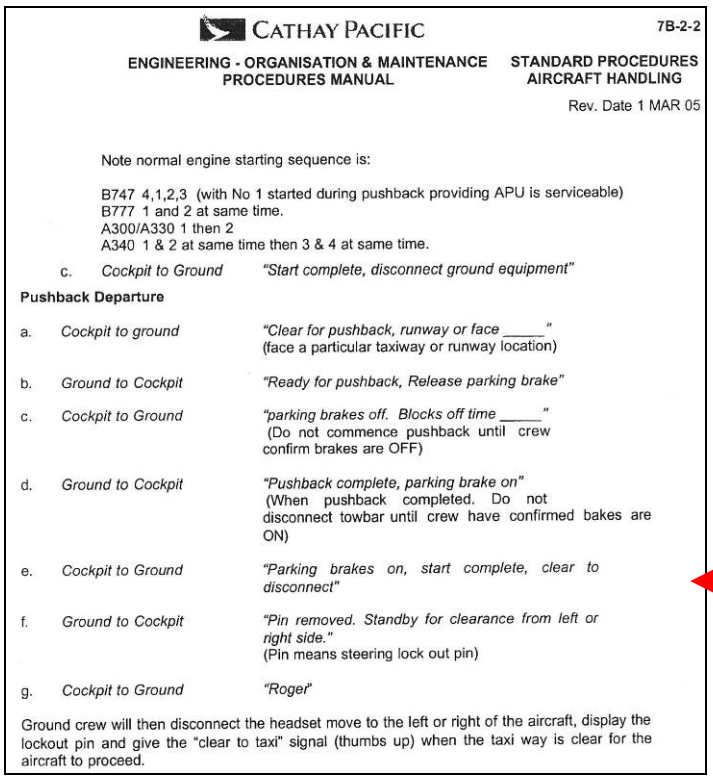
Cockpit to ground Ground to cockpit	Confirm cleared to pressurize (Boeing aircraft only). Cleared to pressurize.
Cockpit to ground	Cleared to pushback Red / Runway 14 / Face North / Starting point 3 etc.
Ground to cockpit	Pushback Red. Confirm park brake off.
Cockpit to ground	[All doors checked closed. Park brake off – off blocks 32.]
Cockpit to ground	Confirm clear to start all engines.

On completion of pushback:

Ground to cockpit	Pushback complete. Set parking brake.
Cockpit to ground	Parking brake set. Start is complete. You are cleared to disconnect.
Ground to cockpit	Roger. All ground equipment clear. Standby for signals on the left/right.
Cockpit to ground	Roger. Signals on the left/right. Goodbye.

Ground crew will disconnect headset and move left or right of the cockpit, display any appropriate gear/ steering pins, and give the clear to taxi signal (thumbs up) when the aircraft is clear of all ground equipment and personnel.

Fig 12. Extract from the OM



CATHAY PACIFIC

7B-2-2

ENGINEERING - ORGANISATION & MAINTENANCE PROCEDURES MANUAL

STANDARD PROCEDURES AIRCRAFT HANDLING

Rev. Date 1 MAR 05

Note normal engine starting sequence is:

B747 4,1,2,3 (with No 1 started during pushback providing APU is serviceable)
B777 1 and 2 at same time.
A300/A330 1 then 2
A340 1 & 2 at same time then 3 & 4 at same time.

c.	*Cockpit to Ground*	*"Start complete, disconnect ground equipment"*

Pushback Departure

a.	*Cockpit to ground*	*"Clear for pushback, runway or face _____"* (face a particular taxiway or runway location)
b.	*Ground to Cockpit*	*"Ready for pushback, Release parking brake"*
c.	*Cockpit to Ground*	*"parking brakes off. Blocks off time _____"* (Do not commence pushback until crew confirm brakes are OFF)
d.	*Ground to Cockpit*	*"Pushback complete, parking brake on"* (When pushback completed. Do not disconnect towbar until crew have confirmed bakes are ON)
e.	*Cockpit to Ground*	*"Parking brakes on, start complete, clear to disconnect"*
f.	*Ground to Cockpit*	*"Pin removed. Standby for clearance from left or right side."* (Pin means steering lock out pin)
g.	*Cockpit to Ground*	*"Roger"*

Ground crew will then disconnect the headset move to the left or right of the aircraft, display the lockout pin and give the "clear to taxi" signal (thumbs up) when the taxi way is clear for the aircraft to proceed.

Differences in descriptions of communication and pushback procedure.

Fig 13. Extract from the technical manual

1.17.4 General - the handling company

The airline and the handling agents for ground and technical services (SGS and STS) were bound by a valid agreement concerning the scope and implementation of contracted services in connection with the airline company's operations at Arlanda.
The agreement was based on the IATA[9] standard handling contract.

[9] IATA: International Air Transport Association.

Tractor driver's duties during and after the pushback

The tractor driver has the responsibility to ensure that the pushback and line-up towing to the "after pushback parking position" is performed safely and according to local instructions and procedures. If the tractor driver observes any problem related to safety, the pushback shall be stopped immediately.

! Caution: If

- **the maximum turning angle is exceeded, or**
- **the nose gear shock strut extends into flight mode during a turn, or**
- **the strut is extended into flight mode when a turn is initiated or this is suspected,**

contact respective carrier's Commander, maintenance or representative prior to flight.

! Caution: Do not perform pushback with the nose gear fully compressed or extended, as this will damage the nose gear internally and cause the aircraft to tip-over on its tail.

The tractor driver shall perform the following work, duties and precautions during and after the pushback:

Step	Action
1	Make sure the clear signal is received before starting the pushback.
2	Make sure any turning limit markings on the nose gear doors are in full view during the entire pushback and line-up towing.
3	Always start the pushback smoothly for the convenience of the passengers and to prevent overload on the nose gear.
4	Avoid pushback through snow banks. Any accumulation of snow in the wheels and brakes must be removed before flight.
5	At the completion of the pushback/line-up towing, slow down the speed smoothly and make sure the nose wheels are centered.
6	Set the parking brakes on the tractor and give the appropriate hand-signal to the dispatcher (fist clenched).
7	Wait for the dispatcher's signal showing that the aircraft brakes are set.
8	In co-operation with the dispatcher, disconnect and remove the tractor and towbar/towbarless tractor from the nose gear tow fitting.

No instruktions concerning safety distance due to limited field of vision from large aircraft.

No instruktions concerning reversing the tow vehicle to a safe distance.

Fig 14. The pushback driver's job description

Dispatcher's duties during and after the pushback

The dispatcher/start-up person shall perform the following duties during and after the pushback:

Step	Action
1	Immediately prior to starting the pushback, make sure that nothing is parked behind the wings by visually checking under both wings.
2	Give the "brakes off" and "start to push" signal to the tractor driver.
3	Monitor that the maximum pushback angle is not exceeded and that the nose gear shock strut does not extend into flight mode.
4	When the nose wheels are straightened and the aircraft has come to a complete stop and the "parking brakes set" signal from the tractor driver is received, order the Commander to set the aircraft brakes.
5	Wait for the "brakes set" signal from the Commander.
6	Give the "brakes set" signal to the tractor driver.
7	In co-operation with the tractor driver, lower the towbar wheels and disconnect the towbar from the tractor to relieve towbar tension, and disconnect the towbar/towbarless tractor from the nose gear.
8	When the towbar and tractor or towbarless tractor is removed clear of the nose gear hazard area, remove the steering bypass/lockout pin **⚠ Warning: Do not remove the steering bypass/lockout pin before the towbar/towbarless tractor is disconnected from the nose gear and is moved clear of the nose gear. Omission to obey this may cause serious injuries to personnel and/or severe damage to the aircraft.**
9	Make sure that the steering bypass/lockout lever returns to normal position for flight (i.e. ensure that the nose gear steering is engaged).
10	Stow the steering bypass/lockout pin on the towbar or tractor.
11	Perform a visual check to secure that the nose gear area is not damaged. Signs of leakage, scratches and dents shall be reported to the Commander.
12	Make sure the tractor and towbar are moved clear of the aircraft out-taxiing hazard area, before the "all clear" signal is given.

Procedure to show steering steering locking pin to flight crew not described.

Fig 15. The technician's (dispatcher's) job description

In the job descriptions obtained by SHK concerning the services provided by the handling agent, only the actions in accordance with the IATA standard are described. In the contract that was signed concerning to negotiations for services, there were no deviations or local routines described. The deviation that can be seen by SHK is that the airline's routine concerning pushback in the technical manual says that the steering locking pin must be shown to the flight crew in connection with the clear to

taxi signal. The airline, and the pilots, claim that this procedure is common practice in connection with the clear to taxi signal from the dispatcher.

In the handling company's manual for this part of the procedure it is described that the pin shall be put on the tow vehicle after removal from the nose wheel. This deviation from accepted practice was explained to SHK as being due to several steering locking pins going missing, and that a procedure was therefore introduced to place the pin straight on to the tow vehicle after removal. Missing or lost steering locking pins had involved a considerable additional cost to the ground handling company.

1.17.5 CRM

The basis for functional and safe crew co-operation is CRM (Crew Resource Management). The general definition of CRM is: *The art of using all available resources in an optimal way.*
Well-functioning CRM is documented as raising flight safety levels. History has many times shown that poor CRM can have disastrous consequences. The cornerstones of CRM in respect of flight crews can be said to be built up from the following components:

Professionalism
Briefing & Communication
Leadership & Teamwork
Situational awareness
Decision-making
Own evaluation

Within commercial aviation, education and training in CRM are mandatory, and must form part of a natural strand of competence development in commercial pilots. In addition to theoretical training, CRM forms part of simulator training and line training, where practice and feedback are the most important components for individuals to understand the concept. Supplementing CRM in basic training are theoretical refresher courses and CRM training in the simulator, which are mandatory elements in continuation training for pilots.

1.18 Other

1.18.1 Equal opportunities aspects

This event has also been examined from the point of view of equal opportunities, i.e. against the background that there are circumstances to indicate that the actual event or its effects were caused by or influenced by the women and men concerned not having the same possibilities, rights or obligations in various respects. Such circumstances were however not found.

1.18.2 Actions taken by airport authorities at the time of the accident

The following sequence of events shows the actions taken by the various involved authorities at Arlanda in connection with the accident. The zero datum point for the timeline is taken as the time of the aircraft's collision with the tow vehicle.

Time	Event
+2 min	CX 064 requests via the control tower to taxi back to stand R9
+3 min	SGS reports to the control tower via telephone that the aircraft has collided with the pushback vehicle and that it “has a tear in the engine”.
+6 min	CX 064 parks at R9.
+12 min	The control tower is informed by SAS that the aircraft is seriously damaged and will not be flying.
+23 min	SAS contacts the ADO (Airport Duty Officer) concerning the accident.
+24 min	The ADO contacts the AFS (Airport Facility Supervisor) who goes to the scene of the accident.
+30 min	The AFS reports that there is extensive damage to both the tow vehicle and the aircraft.
+33 min	The AFS reports to the control tower that “the Cathay is leaking fuel”.
+34 min	The ADO reports to the airport police duty officer, who sends a patrol group to the scene of the accident.
+36 min	The AFS reports to the control tower that the Swedish Civil Aviation Authority (LFV) field unit has been informed, and that a suction vehicle is on its way to remove the spilt fuel.
+42 min	The ADO reports to the BVC (bevakningscentralen – security centre) which sends two cars to the scene of the accident.
+47 min	Cleaning up begins and the taxiway around the accident site was closed.
+57 min	Since the engine is still leaking fuel, the ADO contacts the airport fire and rescue service.
+1 hr 3 min	The airport fire and rescue service arrives at the scene of the accident and remains there for 1 hour and 20 minutes.

1.18.3 Environmental aspects

After the collision a length of about 150 metres of the ramp and the taxiway became contaminated with the jet fuel that leaked out of the damaged engine. It has not been possible to determine the amount of fuel. The total area that was contaminated can, depending on the width of the fuel trail, be estimated as being between 50 m² and 100 m².

Fig 16. Fuel trail after absorbing agent had been applied.

The fuel spillage was dealt with by the Swedish Civil Aviation Authority (LFV) field unit. It is not known how much fuel could have soaked into the surface. According to AR-11-2000, item 3.1, cleaning up of aviation fuel, those who caused the spillage must ensure that it is collected and disposed of. In the case of spillage of aviation fuel exceeding 10 m², it must be taken care of by the airport rescue services who must be called to the scene.

1.18.4 Procedures for raising the alarm – personnel on the ramp

AR 09-2000, item 2.4 states the alarm procedures for personnel who are working "Airside", i.e. within the areas at Arlanda airport where there are aircraft movements. In respect of the alarm criteria in the case of accidents or incidents these are expressed as follows: "Always call 112 in the case of fire or other danger." The regulations do not contain any descriptions, or examples of what "other danger" means from the fire protection viewpoint in an airport or in the vicinity of aircraft during engine starting or taxiing.

1.18.5 Procedures for raising the alarm – air traffic control

Air traffic control is a central authority in respect of the monitoring and co-ordination of all movements within the airport. The part of the airport that is provided for the take-off, landing and taxiing of aircraft is called the maneuver area. However, this area does not include ramps, parking areas, departure preparation areas or aircraft paths. Within the maneuver area, air traffic control is responsible for the safe passage of all aircraft and vehicles. This responsibility also includes calling out the rescue services within the entire airport area in the case of danger due to crashes or other accidents.

The alarm procedures are collected in the air traffic control operations manual, part 3, section 11 – Appendix A, and consists of guidelines when the rescue services are to be called out. The procedures mainly concern two areas; events on the ground and reported or suspected risk situations involving airborne aircraft.

The list of events on the ground contains among other things alarm procedures in the case of fire and running off the runways or taxiways. There is no specific item in respect of collisions involving aircraft on the ground.

1.18.6 Measures taken

<u>The airline</u>

- The pushback procedure has been changed,
- the communications procedures between the pilots and technician/dispatcher have been changed and clarified,
- the normal and expanded checklists have been changed – the all clear signal is now a mandatory item in the after-start checklist.

<u>The technical handling company</u>

- the communications procedures between the pilots and technician/dispatcher have been changed and clarified.

2 ANALYSIS

2.1 Events on the ground

2.1.1 General conditions

The airline had signed agreements with a number of handling agents at Arlanda airport concerning the handling associated with the company's operations. Among these were agents for both ground handling and technical services. The agreements between the companies were based on the IATA standard agreement which describes what the contracted services should cover.

According to the information obtained by SHK, no supplement or instructions had been written in concerning any special handling or information during pushback and engine starting. The procedures that were described in the manuals of the respective organisations were however found to be so similar that the non-synchronisation of procedures cannot be ascribed as having any decisive effect in this accident case.
Nor can the differences in the aircraft operator's internal regulations in respect of pushback be considered of such a nature that they could have affected the events.

2.1.2 Documentation and job description – ground handling

The job description that the ground handling company had issued concerning pushback was in all its essentials correct in respect of the implementation of the contracted services. It can however be pointed out that the tow vehicle driver's instructions did not contain a procedure for driving the vehicle away to a safe distance. Nor was any information provided in respect of the size of the area in front of and underneath larger types of aircraft that was not visible to the pilots during normal ground operations.

The deficiencies in the above job descriptions were important in the case of this accident, even though they cannot be said to be included as causes of the accident. In this particular case the tow vehicle had reversed a maximum of approximately 9 metres after the tow bar had been removed, for the driver to change driving position. In the case of a distance in excess of 9 metres, the top of the far end of the vehicle would have been visible to the pilots, consistent with the normal settings of the pilots' seats in the cockpit.

The fact that the tow vehicle driver did not reverse further may be ascribed to poor training and lack of information concerning the "blind spot" of larger aircraft. SHK considers therefore that it would be advantageous for the handling company to supplement its training and continuation training with information in respect of these safety issues.

2.1.3 Documentation and job description – the airline

Certain inconsistencies could be found in the manuals where pushback procedures and associated communication were described. In one of the manuals there was no procedure to show the steering locking pin written into the communication. The principle that is common in both manuals is however that the dispatcher is to report to the pilots that he will stand on the left or right side when he is to give the all clear signal.

It can however be noted that there is a conflict in the operational conditions. According to the interview with the F/O it was common practice

for many commanders to say: “Show me the pin – see you on the left/right.” The evident deviation from the documentation, where the dispatcher is to initiate the information, should motivate the company to bring about uniformity between the documentation and actual practice.

2.1.4 Documentation and job description – technical handling

The job descriptions applicable to the technical services followed the IATA standard agreement, on which the contract was based. An exception was that the procedures did not follow normal practice, in which the dispatcher shows the steering locking pin at the same time as giving the all clear signal, but for economical reasons this had been changed to stowing the pin on the tractor.

In this particular case the altered procedure had no effect on the accident, but SHK wishes to point out that local deviations from standard or commonly used practice should be agreed between the handling company and the airline operator to prevent the risk of misunderstandings or incidents occurring.

This particular technician was not aware of the communication procedure described by the airline, where the dispatcher shall tell the pilots on which side he intends to stand. Although this deficiency was not a contributory cause of the accident, it can hypothetically be said that if this procedure had been followed, it would probably have had a positive effect on the ensuing chain of events.

2.1.5 Personnel of the ground handling company

The person who drove the pushback tow vehicle was under training and his actions were being monitored by a supervisor. After checking, SHK found that both were trained and qualified for their respective duties, but the tow vehicle driver had not driven this type of vehicle before, nor had he worked with this type of large aircraft. However, they carried out their duties in complete accordance with the instructions contained in the handling company job descriptions.

Despite the fact that the tow vehicle driver was undergoing training, the execution of both the pushback and the detachment of the tow bar were not assessed as deviating from the expected standard. The length of time from the aircraft parking brake being applied by the pilots to the tow vehicle being reversed was just under about 30 seconds, which in the circumstances can be considered a relatively short time. The remaining time of just over 30 seconds before the aircraft began to taxi was taken up by reversing the tow vehicle, switching off the engine, applying the handbrake and removing the ignition key.
The driver then went to the other driving position in order to commence driving away. This also can be considered a normal and expected time period for these actions.

When the tow vehicle driver realized that the aircraft had begun to taxi he left the driving position and started to run away. It was not possible during the interviews with ground personnel to determine how close the tow vehicle driver was to being struck by the aircraft. The driving position that the driver had left was severely damaged by the aircraft engine. The side of the vehicle and the driving position at the other end showed no signs of the collision, which depended on the fact that the aircraft was making a turn to the right, so the engine that was damaged moved away from the side of the tow vehicle at the start of taxiing.

It can be said that it was a fortunate circumstance that the tow vehicle driver realized that the aircraft had begun to move forwards. He was sitting in the other driving position with his back to the aircraft and trying to start the vehicle when he saw in the corner of his eye that there was movement behind him. He had also heard that the engine noise had changed. Altogether this means that he had seen the danger and could run to safety. The signs of damage to the tow vehicle show that the aircraft engine struck it at 20-30 cm into the upper front corner and then while turning went away from the vehicle. It is however probable that the still-running engine went past the forward driver's position at a distance of less than one metre, so that there had been an obvious risk of the driver being sucked in if he had not managed to reach safety.

2.1.6. Personnel of the technical handling company

The technician on duty was not normally a part of the "foreign airline group", but had been called in for extra duty because of the time of day of this particular departure. He was trained and authorised to perform the task, although he had never started up the B747 type previously. It was found that there was a certain amount of confusion during engine start, when among other things the technician had to ask in which sequence the engines should be started up. The decision to stand out of view of the pilots during engine starting in order to avoid misunderstanding was made by the technician himself and not based on any job description.

SHK finds that the actions of the technician possibly departed somewhat from those expected, due to his lack of knowledge concerning this type of aircraft and his decision to stand out of view of the pilots. This however did not to any great degree affect the subsequent events associated with the accident. It is however worth pointing out that knowledge of the specific procedures for aircraft engine starting is probably expected to be included in the technical services that are negotiated by an aircraft operator.

When the aircraft began to taxi the dispatcher was also surprised and ran to get to safety. Although he was closer to the engines when the aircraft began to taxi, he was able to see what was happening, so the risk factor was in his case somewhat lower than that of the tow vehicle driver.

2.2 Events in the cockpit

2.2.1 Conditions

The way the relevant company operations duty schedule for Stockholm was arranged meant that the crew had to fly passive to Arlanda before active flying duty commenced. On that particular night the first officer had arrived as a passenger from Munich, and the commander and flight engineer similarly from London. In the case of the latter their flight had been severely delayed, which meant that also the departure of CX 064 was delayed. Check-in and route planning were prepared by the first officer and were dealt with relatively quickly since the aircraft was loaded and waiting. All of the crew had however flown at Arlanda before and were familiar with the procedures and conditions at the airport.

Later on that particular morning the main runway at Arlanda was to be closed for maintenance work. This information had been incorrectly programmed in to certain computer systems as having already happened, meaning that the planned load could not be carried, due to taking off from a shorter runway.

It is probable that at this stage the crew experienced a certain amount of stress, due to problems with their passive transport, hurried flight planning, delays to their own flight and operational problems being the principal factors. It is therefore not excluded that the continued performance of the crew was to some extent affected by stress factors at the start of their duties.

2.2.2 The checklist

The airline company's normal checklist does not contain any item in respect of checking and verifying that the all clear signal has been received. This must be seen as a deficiency in the operational documentation. The fact that the instructions concerning the all clear signal were only present in the expanded checklist showed that in this particular case there was an inadequate barrier to ensure operational safety in connection with start of taxi.

When an aircraft is set in motion it is of vital importance that all surfaces in the risk area are free from obstacles and that the ground equipment is diconnected and removed. In a large aircraft this is difficult to be sure of without outside help, in the form of the dispatcher's all clear signal. A check on this should be an mandatory item that cannot be passed before both pilots have verified it. The additional time spent reading out a "clear signal item" in the normal checklist may be considered as negligible, especially as it is already considered to be a memorised item from the expanded checklist.

2.2.3 Taxiing out

With the support of both witnesses and transcripts from the CVR, SHK considers that it is clarified that the aircraft began to taxi without any all clear signal being given or received. The time from the dispatcher saying: "We disconnect – have a nice flight" until the commander requested permission to start taxiing was 35 seconds. This cannot be regarded as being a long wait, especially considering that most of this time was occupied in reading and performing the "after start checklist".

From the CVR it can also be seen that neither of the pilots said the phrase "clear signal" during the time period in question, which can be seen as almost remarkable. The only communication between the pilots after the checklist items had been carried out was a check that the left and right sides were unhindered. Taxiing then commenced, and a few seconds later the aircraft collided with the parked tow vehicle.

The experience that the commander claimed to have had during a previous departure from Arlanda, when the dispatcher is said to have disappeared, was not supported by the investigation. The technicians interviewed for this particular departure had no memories of a similar event. SHK can however state that the dispatcher's job description neither contained procedures for showing the steering locking pin nor instructions on where he/she should be located.

2.2.4 Fatigue factors

Both the commander and the first officer had been awake for periods in excess of 18 hours at the time of the accident, so that both pilots were affected by fatigue. The time of the accident also fell within the window where the body's biological clock was programmed for its lowest level of activity, when it is known that the human performance level is reduced. The crew had certainly stated in their interviews that they "got rather used to" working at inconvenient times with longer periods of being awake, and time

zone displacement. In the investigations studied by SHK however, it is pointed out that the result is that fatigue itself is not very much affected, only the consciousness of the individual of it.

The time of day along with the length of time of wakefulness make it probable that there was a certain reduction in cognitive function and performance ability when the accident occurred.

2.2.5 *The crew's conditions*

General

In all operations involving aircraft the required safety margins are built in. These can form various kinds of barriers. In this particular case it can be said that a number of safety barriers of various types, on the ground and in the cockpit were breached, where the following factors principally affected the course of events:

- new, and to some extent unfamiliar, ground personnel in the handling company,
- incomplete and unsynchronised documentation between the airline operator and the handling company,
- a checklist in the cockpit without the necessary check items,
- stress factors due to the delayed departure combined with operational problems,
- fatigue factors with the risk of reduced performance capability.

Altogether it can be said that the conditions for the pilots to perform their work correctly in every respect were limited. This can have led to that their concentration in connection with pushback and taxiing out being insufficiently focused on the safety thinking that was necessary. This accident occurrence also shows the importance of having flight safety and flight safety thinking synchronised with operations and the personnel working outside the cockpit.

CRM

Among the most important parts of CRM are communication and teamwork. In this particular case the lack of communication in respect of an all clear signal was obvious during this time period, when this, in accordance with the additional information in the expanded checklist, must be verified. The fact that three flight crew did not react to the fact that an all clear signal had not been given before taxiing out shows that adequate check items on the checklist are often necessary in order to maintain a high level of operational safety.

In an aircraft such as the B747 with three crew members in the cockpit the reading of checklists is part of the teamwork in order to allow functional CRM to be built up. In the mixed flow of items – actions – checks that work with the checklist involves, well-established CRM should catch any incorrect actions or deviations that may occur among the described procedures.

In the case of this accident none of the three in the cockpit noticed that the after-start checklist never was completed, since the instructions in the supplement concerning the all clear signal were neither commented on nor carried out. This deficiency, probably reinforced by fatigue factors, could be founded on CRM problems. In the opinion of SHK the accident serves as an

example of how important it is for an operator to both mentally and practically interweave CRM in all parts of the company's operations.

2.3 Action by the airport authorities

2.3.1 Ground personnel

When the aircraft collided with the tow vehicle, damage occurred that could be seen immediately by the ground personnel. It was also clear that fuel was leaking from the damaged engine. However none of those involved near to the event at stand R9 raised the alarm to the airport rescue services. Fuel flowing out of a damaged engine that is still running, possibly with damaged live electrical wiring, is to be considered as a high risk from the fire safety viewpoint. The witnesses who saw the accident did not have the training or competence to decide whether the situation that had arisen could present a fire risk. In this particular case, nor were the flight crew aware that a collision had taken place, and thereby did not know about the damage to the engine and the fuel leakage.

There are however no instructions or regulations in AR-09 concerning what is to be regarded as a fire risk associated with this type of event. Section 2.4, that deals with raising the alarm says only that the public emergency number 112 must be called in the case of fire or other danger, which must be regarded as both incomplete and inadequate. The airport fire and rescue unit was first called out 57 minutes after the accident occurred, for the reason that the engine was still leaking fuel.

Both training and continuation training should as a matter of course be supplemented by information concerning fire risks, involving raising the alarm with the airport rescue services. The fact that a jet aircraft of B747 type is able to taxi around with fuel leaking out of a running engine without anyone calling the rescue services is not an acceptable safety standard for a major airport. All collision accidents where an aircraft is involved are to be regarded as a possible fire risk and should therefore be a reason for staff to raise the alarm.

The fact that personnel in this particular case did not alarm the rescue services is adjudged to have depended on deficiencies in procedures and training, which led to insufficient knowledge in respect of raising the alarm and fire protection.

2.3.2 Action by air traffic control

Three minutes after the collision it was reported to air traffic control in the control tower that a collision had occurred and that the aircraft had "a tear in the engine". After a further three minutes the control tower heard that the aircraft had suffered "considerable damage". None of this information however prompted any alarm from the control tower to the rescue services. Just over half an hour after the collision it was reported to the control tower that the aircraft was leaking fuel.

The rescue services were not called until 57 minutes after the collision, and this was because fuel was still leaking from the damaged aircraft. Air traffic control was at the outset not informed of the fuel leakage from the aircraft. When they were later told that there was fuel leaking, the aircraft was already parked, which could possibly explain why they did not raise the alarm.

It cannot however be overlooked that an accident with a potentially high risk of fire could take place without the airport rescue services being alarmed.

In the case of this particular accident the level of consciousness of the seriousness of the situation was successively heightened among the bodies involved. The sequence of events can be described as starting out with a simple event that at first did not appear to require any supervision by the rescue services, to an awareness of greater damage which also included fuel leakage in the picture.

SHK cannot assess how close it became to a fire arising, but can say that leaking fuel, possibly heated, pouring into an area around the hot exhaust gases from the engine comprised an obvious fire risk. In this particular case, with damage to the interior of the engine, there was also the risk of ignition due to live electrical wiring being severed. Apart from the fire risk, also other vital parts of the aircraft system suffered damage that placed continued safety at risk.
It is however impossible for an individual air traffic controller to determine and assess these risks in each case, so that the air traffic control operating manual should be supplemented with the need to raise the alarm in all cases of collisions involving aircrafts.

2.3.3 Environmental aspects

It is established in AR 11 that any fuel spillage exceeding 10 m² must be cleaned up and dealt with by the airport rescue services. In this particular case the spillage was greater than this, but the airport rescue services were not contacted to perform the task. The Swedish Civil Aviation Authority (LFV) field unit managed the entire clean-up and the rescue services did not arrive until an hour after the accident, as the engine was still leaking fuel.

SHK has no perception of whether this deviation had any serious consequences from the safety or environmental viewpoints, but can state that the regulations prescribed in AR were not followed.

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 ground personnel were authorised to perform their services.
d) The tow vehicle driver and dispatcher had not previously performed pushback or start-up respectively on the B747 type aircraft.
e) The airline company's procedure descriptions in different manuals did not coincide.
f) The airline company's pilots sometimes executed different communication procedures than those described in the manual, in respect of the all clear signal.
g) The ground handling company manual did not contain information regarding the "blind spot" during pushback of large aircraft.
h) The dispatcher's job description did not contain instructions regarding showing the steering locking pin while giving the all clear signal.
i) The pilots could not see the area under and in front of the aircraft up to a distance of 25 metres from the nose wheel at ground level.

j) Instructions to the pilots concerning the all clear signal were only available as information in the expanded checklist.
k) The pilots had received incorrect operational information concerning the time when the main runway would be closed.
l) The pilots met two of the four criteria in respect of the possible effects of fatigue.
m) Taxiing commenced without a "clear signal" being given and without anyone in the flight crew mentioning that phrase.
n) The flight crew were not aware that a collision with the tow vehicle had occurred.
o) The damaged engine leaked out fuel along a path of about 150 metres.
p) The alarm was raised to the airport rescue service 57 minutes after the accident.
q) Instructions in the fire protection part of AR do not describe sufficiently clearly in which hazardous conditions the airport rescue services should be alarmed.
r) The air traffic control alarm procedures do not cover collisions on the ground involving aircraft.
s) The clean-up did not take place in accordance with the regulations in AR.
t) The police only breath-tested the commander for alcohol, not the ground personnel who were also involved.

3.2 Causes

The accident was caused by inadequate checklists for the pilots in respect of checking that an all clear signal had been received. A probable contribution was that stress and fatigue factors limited the concentration abilities of the pilots.

4 RECOMMENDATIONS

- It is recommended that the Swedish Civil Aviation Authority ensures that the fire safety regulations for Stockholm/Arlanda and other relevant Swedish airports are revised so that collisions involving aircraft are assigned a sufficiently high risk assessment. *(RL 2008:06 R1).*

- It is recommended that the Swedish Civil Aviation Authority ensures that the operating manuals for air traffic control at Stockholm/Arlanda and other relevant Swedish airports are revised so that collisions at the airport involving aircraft are a criterion for raising the alarm with the rescue services. *(RL 2008:06 R2).*

Appendix 1

CX064 (B-HIH) CVR, telecommunications and radio traffic

Headings

Time: Start time in minutes and seconds **local time** of the message.

From: Source of message.

CX064	- Cathay Pacific 064
VP	- Left Side Pilot
HP	- Right Side Pilot
SE	- Flight engineer
PC	- Passive crew member
TWR	- Arlanda air traffic control tower
AFS	- Airport Facility Supervisor
GND	- Ground personnel in contact with CX064
Cub	- Cubic Air Cargo ground personnel
SAS	- SAS traffic office
DO	- Airport Duty Officer, LFV (The Swedish Civil Aviation Authority)

Note: Remarks

VHF	- Arlanda control tower VHF channel
&	- Internal CX064.
T	- Telephone communication

Information: Message written out in plain text.
?? means that it was not possible to interpret the information.
(Parentheses are used to indicate that the translation is uncertain).
[Square brackets are used to denote comments].

All communication within the aircraft comes from the combined low quality track on the CVR that has a recording time of 2 hours. The three detailed tracks with better quality and a recording time of 30 minutes were all recorded over, as the CVR was stopped too late.

The CVR was probably switched on at 03:31:19. This means that communication on the Flight Deck of CX064 was not recorded until after this time. The CVR was probably stopped at 03:38:51 when all the engines were shut down.

The times have been established by correlating with ATC information where the times were recorded.

For information purposes the results from the airline’s read-out from one of the aircraft data recorders (QAR) have been incorporated.

Time	*From*	**Note**	**Information**
02:20:39	TWR	T	Arlanda control tower (Name).
	Cub	T	Hello, (Name), Cubic Air Cargo.
	TWR	T	Hello, can you wait a moment?
	Cub	T	Yes.
02:21:19	TWR	T	Yes, speak.
	Cub	T	CX064 is at R9 just now, Cathay. They need to take off from the big, long runway. Now I'm not so sure of all the names and such, so I apologise straight away. That would be 0119 left, I think it is.
	TWR	T	Yes, it's 01 left, 19 right.
	Cub	T	OK, is that the long ... good ... it's open and they are planned to take off there.
	TWR	T	Yes, it'll be open for three hours and 39 minutes longer.
	Cub	T	Exactly, that's what I wanted ... for ... I got an ACARS message where they can't take off there. And I was then worried that ... we have time 06:00 ... but maybe it's a bit before...
02:22:14	TWR	T	06:00, what? Take-off?
	Cub	T	No, it will close down that ...
	TWR	T	Yes, but then you've got local time. 4 is of course what I use, that's UTC, so 6 local time it'll close.
	Cub	T	Good, because otherwise we have a different payload, and then it's too heavy to take off anywhere else.
	TWR	T	Exactly ... but hang on a moment.
	TWR		AFS Arlanda tower.
	AFS		AFS listening.
	TWR		I just wanted to check with you as you know, but we can of course use the long runway up to 6 o'clock local time, can't we?
	TWR		I don't know if you took it, but I saw the NOTAM was from 04:00 UTC so that should mean that we can take off, it's Cathay I have on the line here wondering, they are a bit worried.
	AFS		Yes, we agreed on 05:30 during the evening, but I can call you back later.
	TWR		No, we'll go with that, so we'll take 05:30. The NOTAM said 04:00 so that's why ...
02:23:47	TWR	T	Yes, I'm back. [to Cubic Air]
	Cub	T	Yes.
	TWR	T	It seems they agreed to close a half hour earlier, so you have about three hours to do it.
	Cub	T	Good. We've also found the crew, so that's perfect. So then I'll hand over responsibility to the captain there so they can manage the conversation with you. Good, thanks.
	TWR	T	Thanks, bye.
02:26:45	AFS		Arlanda tower, this is AFS here again.
02:27:13	AFS		Yes, we can put it off for a little while, there's no ... the reason for us to start a little earlier was that they were going to start removing the power at K09. But nobody's to do anything before I give the all clear, so if you need to start aircraft we do it.
03:24:45	CX064	VHF	Arlanda ground Cathay 064.
03:24:51	TWR	VHF	Cathay 064.

03:24:53	CX064	VHF	Cathay 064 we're on stand Romeo 9 and we are fully ready. And we are going to request runway 19R.
03:25:02	TWR	VHF	Cathay 064 that's copied, startup is approved and you will have runway 19R, call you back shortly with the clearance.
03:25:09	CX064	VHF	Okay, startup approved, and request push, Cathay 064.
03:25:15	TWR	VHF	Cathay 064 pushback is approved.
03:25:18	CX064	VHF	Pushback approved for 19R, Cathay 064.
03:26:08	TWR	VHF	Cathay 064.
03:26:10	CX064	VHF	Cathay 064 go ahead.
03:26:12	TWR	VHF	You have clearance to destination via Babap 2G departure squawk 7330.
03:26:20	CX064	VHF	Cathay 064 is cleared destination via the Babap 2G departure squawk 7330.
03:26:26	TWR	VHF	Cathay 064 correct.
03:31:36	GND	&	Brakes on.
03:31:41	VP	&	Parking brake set.
03:31:57	VP	&	Engine start is complete, clear disconnect.
03:32:00	GND	&	Yeah, we disconnect and have a nice flight.
03:32:02	VP	&	Bye bye.
03:32:03	GND	&	Bye.
03:32:11	HP	&	The after T/O checklist please, eehh, after start checklist please.
03:32:14	SE	&	Nacelle anti ice
03:32:15	HP	&	Off.
03:32:16	SE	&	Aileron and rudder trim.
03:32:17	HP	&	Zero.
03:32:18	SE	&	Electrical.
03:32:19	??	&	No lights, essential normal
03:32:20	SE	&	Hydraulics.
03:32:21	??	&	Auto and normal
03:32:22	SE	&	All engine and control switches
03:32:25	??	&	Storm lights off, adjust the lights if you wish
03:32:31	VP	&	?? your control.
03:32:34	HP	&	My control.
03:32:35	VP	VHF	Cathay 064 taxi.
03:32:37	TWR	VHF	Cathay 064 taxi to holding point runway 19R.
03:32:41	VP	VHF	Holding point 19R, Cathay 064.
03:32:43	HP	&	Clear right.
03:32:44	VP	&	Clear left.
03:32:47			*[According to the QAR read-out made by Cathay Pacific the parking brake is released at this moment, at the same time as the engine power increases.]*
03:32:49	VP	&	Just before we taxi here … just thinking about this here, it's come out as max B two.
03:32:54	HP	&	Yeah.
03:32:56	VP	&	And we thought this was zero wind.
03:32:58	HP	&	Yeah.
03:32:59	VP	&	And we might have a slight tailwind.
03:33:01	HP	&	Okay.
03:33:02	VP	&	Eehh, the charts when we looked at those wouldn't let us go with a five knot tail, even on D4.
03:33:09	HP	&	Okay.
03:33:10	VP	&	So what I … ?? we put that ?? D4 that switch there and then …
03:33:20	HP	&	Then just get D4 thrust …
03:33:22	VP		We can get … D4 thrust. Are you happy with that?
03:33:26	VP	&	We set D … well … we turn it on D2 … we set D4 thrust. It should …

03:33:40	VP	&	It seems odd, doesn't it, on the charts it wouldn't let us do it on max D4
03:33:45	SE	&	There is something wrong with nr 2 engine.
03:33:47	VP	&	Is it just the …
03:33:49	SE	&	No they're all gone, generator has gone off … what's happened to it?
03:33:57	SE	&	Yees. Not …
03:34:00	HP	&	You did request taxy?
03:34:03	VP	&	Yes, yeah. Yeah I know we did yeah.
03:34:05	SE	&	?? it's just gone, no fuel.
03:34:09	VP	&	Okay, hang on to that, just, do you want to stop here.
03:34:16	VP	VHF	Cathay 064 we have a slight problem we just like to hold on the taxiway, we may have to go back on the gate.
03:34:23	TWR	VHF	That's copied.
03:34:24	PC	&	Feels as if we've run over something. Feels if, you know, gone over the landing gear ??
03:34:29	TWR	VHF	Quality 538B yes, Cathay is holding there on Uniform so proceed in via Uniform and then join the apron via Uniform Charlie.
			Okay copied, so via Uniform onto the apron Uniform Charlie, Quality 538B.
03:34:36	VP?	&	What about the engine ??
03:34.40	SE?	&	I've got engine oil pressure light on fuel fire shut down position ??
03:34:41	CX064	&	Yes, FCU.
03:34:42	SE?	&	Yes, but ?? shut down ?? stopped ?? no fuel.
03:34:47	VP	&	And we don't know why it's failed.
03:34:48	SE	&	So you need to do a shut down check on it.
03:34:51	VP	&	Engine failure checklist.
03:34:53	SE	&	Roger.
03:34:55	VP	&	Engine failure checklist number two.
03:34:57	VP	&	Number two thrust lever.
03:34:58	HP/SE	&	Checked.
03:34:59	VP	&	Number two start lever
03:34:59	HP/SE	&	Checked
03:35:00	VP	&	Cut-off.
03:35:02	VP	&	Should we get back on the gate ??
03:35:05	CX064	&	??
03:35:06	SE	&	The fuel valves are both … were both open, and …
03:35:07	CX064	&	Wait, there's a man.
03:35:12	CX064	&	He's waving to you.
03:35:13	CX064	&	And yet you had no fuel flow.
03:35:16	VP	&	Yeah, let's go back on the gate and we can have a look.
03:35:19	VP	VHF	Cathay 64 we like to return to the gate.
03:35:25	TWR	VHF	Cathay 064 that's copied, you have traffic opposite going to … yes take first left in to R9.
03:35:35	VP	VHF	Yes we'll just go left and left R9.
03:35:38	TWR	VHF	And Quality 538B give way to the Cathay turning in to the apron again going for R9.
03:35:42	HP	&	Clear right.
03:35:45	Q538	VHF	Of course we will 538B.
03:35:49	SAS	T	Hello (Name) SAS here, traffic office.
	TWR	T	Hello.
	SAS	T	Do you have contact with Cathay Pacific, CX064? They've had to stop out there, haven't they?
	TWR	T	Yes. He says he's coming back to the gate.
	SAS	T	Well, that's great, he ran into our pushback truck before he got away there.
03:36:06	TWR	T	Really.

	SAS	T	He just turned sharply and went, before the guys managed to get out of the way, so he has a tear in the engine.
03:36:10	TWR	T	OK, perhaps he knows about it, or…?
	SAS	T	Yes, good, so you won't let him go.
	TWR	T	No, he's going back now.
	SAS	T	That's good, thanks, bye.
03:36:18	TWR	T	Bye.
03:36:20	TWR	T	Arlanda control tower (Name).
	SAS	T	You must stop Cathay 063 immediately because he hasn't seen that he's run into the pushback.
03:36:28	TWR	T	No, he's on the way back to the gate, so I think he does know something.
	SAS	T	Good, because they just called me at the office here ...
03:36:50	SAS	T	He set off without an OK from the ground dispatcher ... you know, he's the one who should ...
	TWR	T	Yes, I understand, he missed the thumbs up.
	SAS	T	Yes, and the pushback was still there and he set off on the engine.
03:37:04	TWR	T	Was it you who talked to the tower earlier tonight, he has of course time ... but now it's definitely off, because you don't fix that in a quarter of an hour.
03:37:14	SAS	T	No, I don't know what's wrong with it, we can't say just now...
03:37:18	TWR	T	But, is there anyone out there to talk to him?
	SAS	T	Yes, they have both a ground engineer, and then they have others so that ... from Cathay, so that ... but he can't take off anywhere else because we have ... he has 99 ... we have a payload of 99 if it's a dry take-off runway, any other, 99 ton, but now he has I think 103 or something.
	TWR	T	But then he'll have to …
03:37:54	SAS	T	In that case we'll have to unload, that's all there is to it. But, we'll have to see what happens ... bye.
03:38:01	TWR	T	Bye.
03:35:54	HP	&	I thought the bumps that…. was just … you know, me turning in acute angle.
03:36:00	VP	&	Yes I think it was and I think it was purely coincidental.
03:36:10	??	&	He's going to get into his van again now so …
03:36:15	VP	&	?? didn't release the ground crew (but I did do that) people have died doing that.
03:36:23	??	&	?? taxi ?? taxi instructions ??
03:36:26	??	&	No they don't have, no it's fine.
03:36:40	VP?	&	As we go in could we just do the … after landing checklist just for …
03:36:46	SE	&	There's a lot of fluid there …
03:36:48	VP	&	Yes, there's something there isn't it.
03:36:51	??	&	Judder, spot in the … there isn't it.
03:36:59	SE?	&	Yeah, spot in the ??
03:37:02	??	&	So I need to switch these things off don't I.
03:37:06	SE	&	After landing checklist (now)
03:37:14	SE	&	Ignition is off, ?? steering, (straight) lights
03:37:20	??	&	Off.
03:37:21	??	&	Flaps.
03:37:23	??	&	?? [noise that could be the flap handle]
03:37:25	SE	&	Speed brakes.
03:37:28	??	&	Yeah, down.
03:37:29	SE	&	Radar to standby. Outflow valves are open.
03:37:33	HP?	&	It's only got guidance on your side here.

03:37:36	??	&	?? actually.
03:37:41	VP	&	?? beacons, strobes, lights are all off, off, off. Shall I take it see if I can … I've got it.
03:37:51	HP	&	You have control.
03:37:52	HP	&	Clear right.
03:37:53	VP?	&	?? there isn't any guidance on at the moment so I'll just … I'll just guess it.
03:38:09	VP?	&	??
03:38:11	SE	&	Just starting the APU now.
03:38:14	VP	&	There we go.
03:38:25	SE	&	Just starting the APU now.
03:38:26	VP?	&	Okay..
03:38:29	VP	&	?? (I'll) just leave number four oh well you're on ??
03:38:33	HP	&	Well we've got ?? just leave number 4 if you like.
03:38:36	SE	&	Okay, ready for shutdown.
			[The CVR presumably stops when all the engines stop, i.e. after this moment there is nothing on the CVR concerning this particular event]
03:44:43	TWR	T	Arlanda control tower (Name).
	AFS	T	Hello (Name), (Name) AFS.
	TWR	T	Hello.
	AFS	T	Has something happened to the Cathay?
	TWR	T	Yes. Have you heard something, or?
	AFS	T	Yes, I heard just now that it was (ADO) who called.
03:44:59	TWR	T	Yes, it seems that they ran into a tractor. Did you hear that or?
	AFS	T	That's just what I heard, that they have damaged one engine.
03:45:09	TWR	T	It looks like he won't get away, repairing an engine ... I don't know at all how serious it is because he doesn't seem to have noticed it himself even when he taxied out ...
	AFS	T	But how on earth is it possible ...
03:45:25	TWR	T	He was in so much of a hurry so it ... yes ... not good, not good. But ... er, I ...
03:48:38	AFS	T	It seems that I should go to the southern ramp. Or the ramp, anyway.
	TWR	T	Exactly, he's on R9.
	AFS	T	But he's gone back in again, so nobody needs marshalling or anything like that?
	TWR	T	No, he went back to the gate.
03:45:48	AFS	T	Good, or no, it's not good but I know that. Bye.
03:45:52	TWR	T	Bye.
04:06:02	AFS		Arlanda tower, AFS.
04:06:06	TWR		AFS, tower.
04:06:09	AFS		Stop at Romeo, Uniform Echo would like to come out to Uniform and look, there is ... was fuel leakage from the Cathay.
04:06:19	TWR		AFS, drive out to Uniform.
04:06:24	AFS		Drive out to Uniform, AFS.
04:09:04	AFS		Arlanda tower, AFS.
	TWR		AFS, speak.
04:09:12	AFS		I'm closing Uniform between Uniform Delta and Uniform Echo because there's fuel lying where I am standing now. I've spoken to field, they're on the way out with Absol and a suction vehicle so we can take it away as soon as possible, but no-one should drive here the way it is now.
04:09:32	TWR		That's understood, thanks.

04:09:40	AFS		Arlanda tower,AFS, so you have the time for Sierra?? there?
	TWR		He's landing in 4, 5 minutes.
04:09:50	AFS		Thanks for that.
04:48:55	TWR	T	Tower (Name).
	DO	T	Good morning (Name), (Name) DO. I'm standing here on ramp Rudolf next to the little jewel we have out here.
	TWR	T	Can't he get away?
	DO	T	No, no, they have enormous damage to one engine, and it's leaking fuel so it looks like it'll have to stay here. But, my question to you is, we are wondering a bit about what was said between the captain and the tower.
04:49:26	TWR	T	He hasn't said anything to me, he has just said that he needed to go back to the gate. He said nothing about running into anything.
04:49:35	DO	T	Han sa ingenting ... men går det att spara bandet från det att han begärde pushback?
	TWR	T	Everything is on record.
	DO	T	Everything is on record ... sso we kake sure it's there, so to say, if it
	TWR	T	Yes, he just requested taxi, and then said that we have a small problem, he said, we have a small problem we need to go back to the gate, he wanted to go back to the gate.
04:50:02	DO	T	OK, but just for ... you can of course hand over ... the shift supervisor perhaps hasn't arrived ... maybe you're the shift supervisor?
	TWR	T	No, they haven't arrived yet.
	DO	T	No, OK, but just so that we ... how long is the tape preserved?
	TWR	T	A month.
	DO	T	All right, so we can go back home whenever we want.
	TWR	T	Yes.
	DO	T	All right, perfect (Name). Thank you very much, goodbye.
04:50:21	TWR	T	Bye.

Statens haverikommission
Swedish Accident Investigation Board

Appendix 2

Comments from accredited representative at Hong Kong CAD.

Appendix to report RL 2008:06e, concerning collision between aircraft B-HIH and a tow vehicle at Stockholm/Arlanda airport, AB county, Sweden on 25 June 2007.

Due to different circumstances the comments were not attached in the report. The comments from the accredited representative at CAD (Civil Aviation Department) are therefore attached as a later published appendix to the report.

香港特別行政區政府
民航處
Civil Aviation Department
The Government of the Hong Kong Special Administrative Region
飛行標準及適航部 Flight Standards and Airworthiness Division

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27 August 2008

Statens haverikommission
Swedish Accident Investigation Board
Teknologgatan 8 C
P.O. Box 12538
SE-102 29
Stockholm
Sweden

For the attention of Mr. Stefan Christensen, Chief Operative Investigator Aviation

Dear Sir,

B-HIH Accident at Stockholm Arlanda Airport on 25 June 2007

Thank you for the opportunity to comment on the Draft Final Report (the Report) on the captioned event. In line with the spirit of Annex 13 to the Convention on International Civil Aviation, we sent a copy of the Report to Cathay Pacific Airways Ltd (CPA) and we now attach a copy of their comments, which we consider relevant, for your consideration.

Our comments on the Report are as follows:

1) We note from the Report that the damage to the aircraft was limited to the left inner engine and that there was no injury to persons. We would therefore be grateful to know the rationale for categorizing the occurrence as "accident" vis-à-vis the definition of accident under Annex 13.

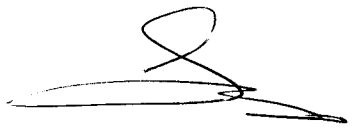
2) Findings in paragraph 3.1 of the Report collectively indicate that there was poor communication between the flight crew and the ground handling crew, compounded by non-adherence to Standard Operating Procedures by both flight crew and ground handling crew. Furthermore, we note from the Analysis in paragraphs 2.1.5 and 2.1.6 and the Findings in paragraph 3.1 d) that two of the ground handling crew had not previously performed engine start and push back on the B747 aircraft type, and more importantly not at night. We therefore have difficulty in agreeing with paragraph 3.2 that the accident was caused by inadequate checklists for the pilots in respect of checking that the all clear signal had been received. We are of the view that the cause or causes should be established with due consideration of all factors and supported by the facts established in the Findings.

/Cont'd. .....

3) Paragraph 3.2 further states that "a probable contribution was that stress and fatigue factors limited the concentration abilities of the pilot." It is noted that the crew had been rostered to have adequate rest and there was no evidence in the report that the crew suffered from fatigue.

We would therefore much appreciate, in due course, your consideration of the above comments.

Yours faithfully,



(K C Man)
for Chief Inspector of Accidents

Encl.

c.c. Mr. Richard Howell – Head of Corporate Safety, CPA

Statens haverikommission
Swedish Accident Investigation Board

Appendix 3

2008-11-05

Comments from accredited representative at Hong Kong CAD

Appendix to report RL 2008:06e, concerning report between aircraft B-HIH and a tow vehicle at Stockholm/Arlanda airport, AB County Sweden, on 25 June 2007.

On explicit request from the accredited representative at CAD (Civil Aviation Department), also the comments from the airline concerned are attached to the report. These comments were attached to the comments from CAD (appendix 2 in this report).

The comments from the airline concerned, attached as appendix 3 in this report, are solely to be regarded as comments from the accredited representative at Hong Kong CAD.

CPA Comments on SHK Report

Cathay Pacific Airways has formally received the draft version of the Factual Information section of the final investigation report from the SHK Swedish investigation authority. We have also received copy of the complete final report via HK-CAD, which was transmitted to us in accordance with ICAO Annex 13. Although the majority of our comments were initially based on the formal invitation to comment on the Factual Information only, we are including comments which are relevant to the Final Report as a whole, including the Analysis, Findings and Causes, and Safety Recommendations sections of the report. Whenever appropriate, we have included information in support of our comments.

Our comments are limited to those issues presented or discussed in the report which affected CPA's operation, or fall under CPA's control or area of expertise. Those comments are offered with the view to improve the accuracy, fairness and comprehensiveness of the report and should in no way be taken as criticizing the investigation or diminishing the seriousness of this incident, as evidenced by our extensive participation and support of the investigation, as well as the scope of the safety preventive measures taken to date. Our comments also include additional information which will help enhance the usefulness of the report.

We trust SHK investigation authorities will consider our comments favorably and include them in the final report.

GENERAL

Correspondence
Hard copy of the draft Final Report was sent to Cathay Pacific Cargo. As per Cathay Pacific Airways' SMS and likely in similar fashion as to other airline operators, CPA Corporate Safety Department (CSD) is the department responsible, on behalf of the CPA CEO and AOC holder, for the safety oversight and the coordination with foreign investigative authorities.

Consequently, we suggest that all future correspondence be directed to the attention of the following :

Cathay Pacific Airways
Head of Corporate Safety
CSD – 1/F, Central Tower
Cathay City
8, Scenic Drive
Lantau
Hong Kong SAR

Opportunity to comment on the draft Final Report
CPA is greatly disappointed in not having been given by SHK the opportunity to comment formally on all sections of the draft Final Report, especially since a copy of the complete report has been provided to HK-CAD as ICAO Annex 13 Accredited Representative. CPA considers this severely limiting and unfair, as well as not being in compliance with the spirit of ICAO Annex 13, which recommends that a copy of the draft Final Report be communicated to the operator. In keeping with world-recognized safety investigation best practices, one would expect that the format of a Final Report, whether in draft or other form, would include all sections described under ICAO Annex 13, not just the Factual Information section.

This was discussed previously with the IIC and, in the course of the investigation, it was explained that SHK statutes and procedures effectively limits comments from interested parties to the Factual Information section of the draft Final Report. In keeping with ICAO Annex 13, CPA suggests and exhorts SHK to consider reviewing their statutes and procedures, with the view to allowing all interested parties to comment on the draft Final Report as a whole.

Definition of Accident
In the title page and throughout the report, reference is made to the occurrence being an 'accident'. CPA disagrees as this occurrence clearly does not meet the definition of 'accident' as per ICAO Annex 13 in that :

- no person was fatally or seriously injured; and,
- damage was limited to the engine and associated cowling.

Notwithstanding the above, CPA recognizes that the occurrence was serious given the potential for greater injury or damage. Nonetheless, CPA suggests that SHK considers replacing in the final report all mention of 'accident' with 'incident'.

FACTUAL INFORMATION

Persons on board
There were five persons on board the aircraft – three operating crew members, and two non-operating crew members who were positioning to DXB after having operated into ARN. Passengers are not carried on CPA cargo flights. In the tabular information provided on p. 4 regarding Persons on board, as well as in other sections of the report (i.e. s.1.1.1), the two non-operating crew members are described as passengers. CPA suggests that the report be amended to reflect that the two non-operating crew members were re-positioning.

Damage to aircraft
In the tabular information provided on p. 4 regarding Damage to aircraft, CPA suggests that 'Substantially damaged' be replaced by 'Substantial damage limited to engine No. 2'. Other sections of the report should also reflect that the damage was limited to the aircraft No.2 engine.

Cabin crew members
In the tabular information provided on p. 4 regarding Cabin crew members, CPA suggests adding 'Not applicable'.

Operating crew basing
Section 1.1.1 of the report indicates all three operating crew members as being based in England. This is not accurate and the report should be amended to reflect the following :

- Captain : FRA-based but had arrived from LON on passenger service
- FO : FRA-based and had positioned from MUC to ARN on the subject aircraft
- FE : LON-based and had positioned from LON with the Captain

Problem during flight preparation
Section 1.1.2, last sentence - the report states that 'the problem could be resolved'. This leads to an ambiguity as to whether the problem was effectively resolved or not. CPA suggests that the report reflect that the problem 'was' resolved after communication with OPS.

Pre-engine starting checklist
Section 1.1.2, 2nd para., 1st sentence – the correct CPA terminology for the subject ckecklist is 'Before Start Checklist'.

All clear visual signal
Section 1.1.2, 2nd para., last sentence – describes the all clear signal as meaning that 'everything is ready for the aircraft to taxi under its own power'. CPA suggests that this statement be more specific and consistent with CPA procedures, and that the report be amended as follows : '...the aircraft is clear from all ground personnel and equipment, and the flight crew can proceed for the flight and taxi the aircraft under its own power'.

Number of ground personnel present for the pushback procedure
Section 1.1.2, last para., 1st sentence – this sentence is incorrect and leads to ambiguity. The report should reflect that there were three (not two) ground personnel present for the pushback procedure – a ground engineer (referenced as 'SAS dispatcher' in the report), and a tug driver under instruction and his supervisor.

Aircraft manoeuver during pushback and taxi
Section 1.1.3 – the report should more accurately and comprehensively describe the intended manoeuvering of the aircraft for pushback and taxi out – i.e. aircraft pushed back from the stand and turned 90 degrees to the right, after which the aircraft would taxi-out with an immediate 90-degree right turn out of the apron, followed by a 90-degree left turn onto the taxiway. The inclusion of a diagram may be helpful.

CPA Comments on SHK Report

Ground manoeuvering by flight crew
Section 1.1.3, 1st para., 2nd sentence – The flight crew does not control nor manoeuver the aircraft during pushback; this is accomplished by the ground crew using the tug. The PF is normally the flight crew responsible for coordinating with the ground personnel during the pushback, and for taxiing the aircraft once the pushback is completed and the tug is disconnected. However, on the B747 aircraft, the Captain is initially responsible for cockpit-ground coordination until the pushback is completed and the aircraft is ready to taxi-out. The Captain will then transfer control over to the PF (FO), as was the case during the occurrence. The report should be amended accordingly.

Ground vehicle driver
Section 1.1.3, 1st para., 4th sentence – 'The driver of the vehicle' – the report should specify which of the ground personnel (trainee or supervisor) was actually driving the vehicle.

Location of the driver supervisor
Section 1.1.3, 1st para., last sentence – 'The pushback driver monitored the procedure while standing some distance…'. This raises questions as to how far away from the tug driver was the supervisor at the time, and whether this may have affected the effectiveness of the supervision of the trainee driver. This should be clarified in the report.

Park brake application
Section 1.1.5, 31 :41, 2nd sentence – The Captain applied the park brake.

Clear Right, Clear left
Section 1.1.5, 32 :43 and 32:44, – The statements are reversed – i.e. the FO first prompted 'Clear right', followed by the Captain responding 'Clear left'.

Captain's attention fixed on the direction of the turn
Section 1.1.5, Approx 33 :00, last sentence – 'His (the Captain) attention was fixed on the direction of the turn (to the right)'. It would be difficult for an external observer to effectively determine if the Captain's attention was 'fixed' to the right. The report should more factually describe that during the turn, the Captain directed his attention towards the direction of the right turn.

Injuries to ground personnel
Section 1.2.2 – although this may be debatable, in our opinion and as stated in s1.15.2 of the report, shock does not constitute an injury, however minor. The report may state that ground personnel suffered from shock following the occurrence. However, the report should reflect that no injury was sustained by the ground personnel.

Flight crew duty schedule - fatigue
The factual information section of the report includes a wealth of information on fatigue, and this is likely in preparation for further discussion in the analysis and possible findings of fatigue as being cause-related.

The report indicates that in the case of the the FO and the FE, there was no information concerning the time they were awake prior to the occurrence. All flight crew member stated they were not fatigued at the time of the occurrence. Review of the duty roster for the flight crew indicates ample time had been provided for proper rest prior to duty period. Yet the report suggests that, in the case of the FO, it was estimated that the FO was awake for 18 hours, without providing any clue as to the basis for this estimation. The report further states in s.1.13.3 that both the Captain and the FO had experienced periods without sleep lasting or exceeding 18 hours. These different statements contradict each other and are confusing. In the absence of further evidence, the report should clarify that the Captain stated he had remained awake during the day, and that no determination could be made as to the hours of wakefulness for the FO and FE.

Circadian low – The possible effect of night circadian low should be calculated based on the crew original (UK) body clock, not Sweden. There is one-hour time difference between UK and Sweden. Consequently, the flight crew were at the beginning of their night circadian low cycle at the time of the occurrence, not in the middle of it.

Ground crew duty schedule - fatigue
In all fairness, the duty schedule of the ground crew should have been investigated for the possibility of fatigue in similar fashion and to the same extent as that for the flight crew.

Aircraft engine – Rolls-Royce
The report correctly indicates that the aircraft was equipped with RB211-524D4 engines, which are manufactured by Rolls-Royce, not by Pratt and Whitney as indicated in the report.

Aircraft after collision
S. 1.12.2, Fig. 8 – legend should be translated in English.

Crew breath testing
S. 1.16.3, 1st para. – report indicates that all three flight crewmember were subjected to breath test by the police. Information supplied by crewmembers suggest that only the Captain was subjected to this test. This should be confirmed and clarified in the report.

ANALYSIS

We feel that the report's analysis and ensuing conclusions emphasizes fatigue at the expense of other contributing factors. The analysis also includes some new information that is not presented earlier in the factual information section of the report. In addition, those findings which are supported by evidence should include some concluding statement as to their significance/contribution to the occurrence.

The following comments are presented in topical fashion and include information which would, in some cases, need to be presented in the factual information of the report, in support of the discussion in the analysis.

Safety action taken
In 2007, CPA experienced a series of ground incidents related to pushback or taxi-out, including this occurrence. Interestingly enough, there appears to have been a similar worldwide increase in ground incidents during that period in 2007. With the exception of the ARN incident, none of the CPA incidents resulted in damage or injury. However, the risk potential was considered sufficiently high to warrant further investigation, which highlighted potential safety issues with regard to ground-cockpit coordination.

As result, the CPA pushback procedures were reviewed and the flight operations OM and the engineering EOMP were amended to correct minor inconsistencies. In addition, the normal checklist for all aircraft types in CPA fleet were reviewed and amended as follows :

- Addition of pilot acknowledgement of the final all clear visual signal from the ground crew as the last call-response item in the normal After-Start checklist. This was done with due consideration to checklist conciseness, with the view to preclude the possibility of pilot omission of this procedure which is otherwise called for in the OM.
- Requirement to obtain ATC taxi clearance only after completion of the After-Start checklist. This was done to effectively separate in time and avoid the possibility of confusion between the moment pilots acknowledge the final all clear visual signal by the ground crew, from the moment when a visual check for obstacles is routinely performed by the pilots immediately prior to aircraft movement (i.e. taxi-out).

Additional safety action being taken by CPA Engineering is to provide contracted ground service providers with a copy of the CPA EOMP and training package on CD-ROM, and to specify in the contractual agreements that ground handling personnel must be trained and knowledgeable, and that the ground handling services to CPA aircraft are to be provided in accordance with CPA-EOMP. This has already been taken with regard to ground services being provided to CPA flights in ARN.

We recommend that, as per the practice of several safety investigation agencies, pertinent safety action taken be more appropriately included in the Safety Recommendation section of the final report.

CPA Comments on SHK Report

Cockpit checklist (normal/abbreviated)
The normal checklist is the only checklist used by pilots during normal operation, to ensure that the aircraft is adequately configured in preparation for the next phase of flight. It is not possible, nor is it desirable, for the normal checklist to detail and include all operational steps and procedures. Instead, that information is presented in the aircraft FCOM3 (expanded checklist) for all info which is aircraft type-specific, and in the CPA operations manual (OM) for company-wide operational info.

Completion of After Start checklist
The report indicates that the After-Start checklist was not completed. This is inaccurate as review of the transcripts indicate that the crew completed all items in the normal After-Start checklist. This should be clarified in the report.

Acknowledgement by pilots of the final all clear visual signal from the ground engineer
The crew omitted to acknowledge the final all clear visual signal from the ground crew prior to aircraft taxi-out. As this procedure is not aircraft type-specific, it is contained in the CPA Operations Manual (OM, Vol. 2 Pt. 2, s12.6), and referred to in the B747 FCOM3 expanded checklist. At the time of the occurrence, this check was not included as a call-response item in the normal checklist. Instead, pilots were expected to recall and execute that procedure from memory after completion of the After Start checklist and prior to initiating taxi-out.

It had been remarked that CPA had operated a significant number of years with this procedure not included in the normal checklist without any problem. Other airlines also do not currently have this procedure in their normal checklist, seemingly with no ill effect. After due consideration, CPA considered it desirable to include that procedure as a step in the normal checklist.

The fact that this procedure was not included in the normal checklist, as is the case for other airlines, cannot be taken as a causal factor. However, CPA agrees that this defense was absent at the time of the occurrence and that it can be identified as a possible risk factor in this incident in that the likelihood of crew omitting that procedure was increased.

FO prompt for Clear R/L check immediately prior to releasing park brake for taxi
The B747-FCOM 3 (expanded checklist) states that the parking brake may only be released and taxi commenced after ATC taxi clearance has been received and understood by the crew and both pilots have confirmed "clear left/clear right" as appropriate. This visual check for obstacles on both sides of the aircraft is not included as an item in the normal checklist. This check is recalled by the PF from memory and immediately precedes any aircraft movement. This check is ingrained during pilot training and prompting by the PF for 'Clear R/L' will immediately elicit response from the other pilot to check and confirm that the corresponding side is clear from obstacle.

Acknowledgement of the ATC taxi clearance is also required prior to initiating taxi. At the time of the occurrence, there was no definite moment set in the pre-departure checklist flow as to when the crew were to request for ATC clearance to taxi. As result, receipt of ATC taxi clearance could occur at any time after beginning pushback.

In this case, the crew requested and obtained ATC taxi clearance after having completed the After Start checklist, and this was not a factor in the incident. However, the FO (PF) prompting for the Captain to check that the left side of the aircraft was clear from obstruction may have precipitated the events and contributed to the omission of the acknowledgement of the final all clear visual signal from the ground engineer.

In the flow of normal line operations, the final all clear visual signal from the ground crew often coincides closely with the PF prompting for clear R/L prior to taxi. Investigation into other ground incidents has revealed that some pilots may have on occasion confused the checking for obstacles prior to aircraft movement with the receipt of the final all clear visual signal from the ground crew. It was also found that, given the conditional relation between taxi clearance and taxi initiation, as well as their relative proximity in time, the early receipt of ATC taxi clearance before completion of the After Start checklist may also have been, in some cases, a factor in the premature initiation of taxi.

In order to prevent possible confusion between the receipt of the final all clear visual signal from the ground engineer and the Clear R/L procedure, the two have been separated by:

1- including the acknowledgement of the final all clear visual signal from the ground engineer as the last item in the after-start checklist, and

2- requiring that the ATC taxi clearance be obtained only after the after-start checks has been completed.

Crew omission as pivotal/causal factor

The crew omission of acknowledging the visual all clear signal from the ground crew before initiating taxi-out is pivotal and is, in our opinion, the causal factor in this event. Consequently, the report needs to take into consideration and examine all factors which could have contributed to this omission having been committed and remaining unnoticed by the flight crew.

Possible contributing factors to crew omission

As is often the case, none of the following contributing factors, including fatigue, when taken independently, are in themselves sufficient to explain the crew omission. However, the combination of these contributing factors does offer some insight into the circumstances of this incident and the crew omission of the acknowledgement of the final all clear visual signal from the ground crew.

Deviation from CPA ground handling procedures (i.e. signals R/L)

The ground engineer (GE) did not use the CPA procedure when communicating with the cockpit – i.e. the GE did not advise the flight crew to expect an all clear signal from R/L side of the aircraft. This deviation from CPA ground handling procedures was not challenged by the crew at the time. Section 12.6 of CPA OM Vol. 2 Pt. 2 states that while every effort should be made to use standard communication guidelines, in circumstances when non-standard phraseology is used by the ground crew, it may be prudent to use their terminology to avoid further confusion.

Members of the flight crew were aware of previous anecdotal instances where ARN ground handling was not carried out in accordance with CPA procedures, and where the ground personnel in ARN had reportedly left the aircraft prematurely and the flight crew had not been provided with final visual all clear signal before proceeding. These instances had not been reported to the CPA fleet office or Corporate Safety Department prior to the occurrence. The crew knowledge of these anecdotal instances, whether founded or not, may have been a factor in the crew proceeding without having challenged the GE, or acknowledged the final all clear visual signal.

Since the occurrence, CPA pilots have been reminded to report any deficiency in ground handling procedures, and several reports of such instances in ARN and other ports have been filed, giving more credence to the anecdotal instances.

Ground handling services for CPA aircraft in ARN and other ports are contracted. Online access to the CPA-EOMP is provided to all ground handling service providers. The CPA-EOMP contains the ground handling procedures for CPA aircraft. It is not known whether the SAS ground personnel training included the CPA-EOMP ground handling procedures.

Safety action has since been taken by CPA Engineering to provide contracted ground service providers with a copy of the CPA EOMP and training package on CD-ROM, and to specify in the contractual agreements that ground handling personnel must be trained and knowledgeable, and that the ground handling services to CPA aircraft are to be provided in accordance with CPA-EOMP.

Ground personnel and equipment remaining out of sight from cockpit after disconnect

After pushback was completed, the ground engineer contacted the cockpit and indicated that he would disconnect. The report indicates that the tug driver instructions did not contain a procedure for driving away to a safe distance or within view of the cockpit after disconnecting the towbar. The ground engineer unplugged his headset, the tug was disconnected and moved a short distance away. The ground engineer consciously chose to remain near the nosewheel, out of sight from the cockpit until the tug was moved away clear from the aircraft. The tug driver had just gained access to the tug's other driving position when the aircraft began to move.

The absence of ground personnel and equipment within sight of the cockpit was a contributing factor in this incident. The presence of ground personnel or equipment within sight of the cockpit when the

pilots checked for the R/L sides of the aircraft to be clear would have been a positive indication to the pilots that they could not proceed. The pilots would have been alerted to the presence of ground personnel or equipment, and would therefore not have released the park brake and initiated taxi. It is also possible that the absence of ground personnel and equipment from sight may have reinforced the pilot's belief that in ARN, the ground handling was conducted differently from CPA procedures.

The issue of restricted ground visibility from the cockpit was raised and discussed at length at the SHK investigation meeting in Stockholm. It was remarked that contributing to this was the lack of guidance for ground personnel as to the extent of the blind areas around large aircraft such as the B747. It was also remarked that there should be minimum delay between the moment the ground engineer disconnect the headset from the aircraft and the time ground personnel becomes within sight of the cockpit prior to providing the final all clear visual signal to pilots. These two points should be discussed in the report and would be expected to lead to corresponding recommendations from SHK in the report.

Crew performance factors

The report makes allegations that fatigue was a factor and leads the reader into thinking that fatigue may have played a significant part in this occurrence. However, the report does not clearly indicate the nature of the fatigue and its extent, nor does the report indicate how and whether or not fatigue affected the crew performance.

Flight crew roster – All three crew members performed one hour of reserve two days prior the occurrence day; this hour consisted in crew control advising them of their duty for the occurrence flight. On the day immediately prior to the occurrence day, the flight crew were provided with sufficient time to rest prior to commencement of duty.

The crew were rostered as per normal practice for freighter operations. Their roster was well within AFTL limitations and would not have resulted in any acute fatigue. Furthermore, all three crewmembers had several days leave prior to the one-hour reserve day, precluding the possibility of accumulated or chronic fatigue.

Crew hours of wakefulness – According to the report, the Captain stated that he was awake during the day, prior to commencement of duty; the report further indicates that there was no information as to the hours of wakefulness for the FO and FE.

All crew were provided with and were expected to manage properly and take advantage of sufficient opportunity to rest prior to commencement of duty. Althought the Captain admitted to being awake during the day prior to the occurrence, it is not known whether the FO and the FE rested or were awake during the day. Therefore, no determination can be made for the FO and the FE as to their hours of wakefulness.

Time of occurrence – The occurrence took place at night, in the early hours of the morning. It is not unusual for individuals to experience mild level of weariness or tiredness at those times. However, in the absence of other fatigue factors, such tiredness is not expected to unduly affect individual performance. Proper rest taken before will reduce the effect of tiredness.

Circadian low – The occurrence took place during the period of night circadian low. The effect of circadian low varies between individuals and, in absence of exacerbating factors, may result in minor weariness or tiredness. The time of occurrence corresponded to the middle of the night circadian low period for the ground personnel whose body clock would have been accustomed to ARN local time and, given the one-hour time difference, to the beginning of that period for the UK-based flight crew. Consequently, the flight crew would have likely been less affected by the effect of night circadian low than the ARN-based ground personnel.

Crew assessment of own fatigue – The report indicates that all three crew members stated they did not feel fatigued and that it was not a factor in the occurrence. Although individual assessment of own fatigue is not always reliable, the crew considered themselves fit and reported for the rostered duty.

Effect of fatigue on crew performance – There is no evidence as to the flight crew performance having been unduly affected, whether by fatigue or other factors. There is a possibility of fatigue being a contributing factor. However, the nature and extent of fatigue is not clearly expressed in the report.

Review of the transcript indicates normal crew interaction and cockpit flow during the event. Examination of the circumstances does not indicate evidence of fatigue other than possible mild weariness or tiredness, which would be considered normal given the night time at which the flight was departing, and would not be expected to unduly affect the performance of the crew.

Conclusion on flight crew fatigue
Crew fatigue factors appear to be insufficient in themselves to explain the flight crew omission, and other factors must be examined. The statements and conclusion in the report as to stress and fatigue factors having limited the concentration abilities of the pilots are not supported by evidence.

The report should limit itself to indicating that some fatigue-inducing factors were present, and that it is possible that crew may have experienced some mild fatigue in the form of weariness or tiredness, possibly more so in the case of the Captain who had stated he was awake during the day. The report should further conclude that there is no evidence that the extent of fatigue was such that the crew performance was unduly affected, and that fatigue was therefore not a significant factor in the occurrence.

Ground crew performance – The report focuses exclusively on the possibility fatigue performance issue related to the flight crew. There is no information on ground crew duty roster and hours of wakefulness, nor is the effect of night circadian low discussed. In all fairness, fatigue and human performance analysis should have been extended to include the ground personnel as well (duty roster, hours of wakefulness, testing for substance impairment, evidence as to performance being affected, etc).

Time pressure from delay - The departure of the aircraft was delayed about one hour. This was partly due to the Captain and FE having arrived late in ARN due to flight delays from London, and the problems associated with runway take-off performance calculations. The FO had initiated the preparation for the flight, with the help from the crew of the preceding flight, which helped minimize the delay.

Delays to freighter operations can often occur due to many different reasons, some of which are out of the control of flight crew. Although it is likely that the crew felt some time pressure and did their best to minimize further delay, there is no evidence from the transcript that the crew performed their duties with any excessive haste, or knowingly circumvented any procedure.

Distraction - Captain pre-occupation with runway take-off performance calculations
Review of the transcript indicates that immediately after FO's prompt to check R/L prior to aircraft movement, the Captain began talking about the issue of the earlier problems with the runway take-off performance calculations they had experienced earlier. This suggests that the Captain was still pre-occupied by this issue at the time. This may have been a distracting factor that could have prevented the Captain from re-calling the OM and FCOM3 requirement to wait for and acknowledge the final all clear visual signal from the ground engineer.

Inadequate CRM
Review of the transcript suggests that individual crew performance and interaction was normal and that they focussed on their task once the After-Start checklist was completed. The report correctly highlights that the crew would have been expected to alert others to the omission of the final all clear visual signal having been received, yet the report does not offer possible valid contributing factors that would explain this. Instead, the report incorrectly states that the After Start checklist was not completed, and suggests that the crew CRM training may have been deficient. However, the report does not state explicitly in which way CRM training was deficient or contributed to the event, nor is any evidence presented, whether in the factual section of the report or in the analysis, as to CPA CRM training being deficient.

CPA Comments on SHK Report

CPA has a mature, recognized and approved CRM training program. Systemic deficiencies in CRM training, as alluded to in the report, would be remarkably evident in this and other occurrences. Although CRM training can always be improved, no such systemic deficiencies have been identified through CPA SMS and reporting programs. In absence of further evidence, the report can only state that the reason for crew members not alerting the others as to the omission of the final all clear visual signal could not be determined. In addition, the statements in the report as to the CPA CRM training being deficient are not supported and need to be removed from the report.

Other risk factors

The delay in requesting the airport rescue services to respond to the scene of the collision and the ensuing fuel spill increased the exposure of the CPA aircraft and crew, and other personnel to the risk of fire.

CONCLUSION

Additional findings

For the sake of clarity, the following additional findings should be included in the report:

- All three ground personnel were able to move out of harm's way after they noticed the aircraft began to taxi-out. However, they were not able to neither move the tug nor attract the pilots' attention before the collision occurred.
- The left side of the No.2 engine collided with the parked tug as the aircraft was turned to the right soon after initiating taxi-out.

Causal statement

Review of the evidence and discussion reveal that he incident was caused by the crew omission of acknowledging the final all clear visual signal from the ground crew prior to releasing the park brake and initiating taxi.

Possible contributing factors were :

- The delayed departure, which may have exerted some time pressure on the crew in ensuring that no further delay resulted.
- The flight crew awareness of previous anecdotal instances of ground handling procedures not having been carried out in accordance with CPA EOMP procedures and standards.
- The non-adherence to CPA ground-cockpit communications procedures, which created a missed opportunity to remind the flight crew to expect the final all clear signal on R/L side of aircraft.
- The fact that ground personnel and equipment remained out of sight from cockpit after the towbar was disconnected from the aircraft and the ground engineer disconnected his headset.
- The Captain preoccupation with the previous runway take-off performance problem, which likely diverted his attention once the After-Start checklist was completed.
- The F/O prompt for clear R/L check prior to aircraft movement, which was likely the precipitating event.

Possible factors as to risk were :

- The absence in the normal checklist of the acknowledgement of the final all clear signal from the ground crew, which increased the likelihood of crew omission of this OM procedure.
- The delay in RFF responding to the scene of the collision and the ensuing fuel spill, which increased the aircraft and personnel exposure to the risk of fire.

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