FINAL REPORT

TURBULENCE ACCIDENT

TO BOEING 777-200, 9V-SRC

ON AIRWAYS L625 NEAR POSITION ARESI

ON 28 JUNE 2004

AIB/AAI/CAS.018

Ministry of Transport
Singapore

15 July 2005

The Air Accident Investigation Bureau of Singapore

The Air Accident Investigation Bureau (AAIB) is the investigation authority in Singapore responsible to the Ministry of Transport for the investigation of air accidents and incidents to Singapore and foreign civil aircraft in Singapore. The AAIB also participates in overseas investigations of accidents and incidents involving Singapore aircraft or aircraft operated by a Singapore air operator.

The mission of the AAIB is to promote aviation safety through the conduct of independent and objective investigations into air accidents and incidents consistent with Annex 13 to the Convention on International Civil Aviation.

The AAIB conducts the investigations in accordance with the Singapore Air Navigation (Investigation of Accidents and Incidents) Order 2003 and Annex 13 to the Convention on International Civil Aviation, which governs how member States of the International Civil Aviation Organization (ICAO) conduct aircraft accident investigations internationally.

The investigation process involves the gathering, recording and analysis of all available information on the accidents and incidents; determination of the causes and/or contributing factors; identification of safety issues; issuance of safety recommendations to address these safety issues; and completion of the investigation report.

In carrying out the investigations, the AAIB will adhere to ICAO's stated objective, which is as follows:

> *"The sole objective of the investigation of an accident or incident shall be the prevention of accidents and incidents. It is not the purpose of this activity to apportion blame or liability."*

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GLOSSARY OF ABBREVIATIONS

ATC	Air Traffic Control
CMD	Commander
CIC	Cabin Crew In-charge
CVR	Cockpit Voice Recorder
LS	Leading steward
pax	Passenger
PF	Pilot Flying
PIC	Pilot in Command
PNF	Pilot Not Flying
SEP	Safety and Emergency Procedures
SOP	Standard operating procedures
SSFDR	Solid State Flight Data Recorder
UTC	Coordinated Universal Time

BOEING 777-200, 9V-SRC

Classification	:	Accident
Aircraft Type	:	Boeing 777-200
Aircraft Serial Number	:	28999
Registration	:	9V-SRC
Number and Type of Engines	:	Two Rolls Royce Trent 884
Place	:	Airway L625 near position ARESI
Date & Time (Local Time)	:	28 June 2004 at 04.00 am
Type of Flight	:	Public Transport (Passenger)
Persons on Board	:	225
Point of Departure	:	Singapore Changi Airport
Destination	:	Nagoya, Japan

SYNOPSIS

During a flight from Singapore Changi Airport to Nagoya, Japan, a B777-200 aircraft encountered moderate turbulence near waypoint ARESI on airway L625. The occurrence resulted in a cabin crew member sustaining a cut above the left eye and two broken wrists. The cabin crew member was treated in Nagoya and was hospitalised on his return to Singapore.

1 FACTUAL INFORMATION

All times used in this report are Singapore times. Singapore time is eight hours ahead of UTC.

1.1 History of Flight

1.1.1 A Boeing 777-200 aircraft was operating a scheduled passenger flight from Singapore (SIN) to Nagoya (NGO), Japan. The pilot in command (PIC) was the pilot flying (PF) the SIN-NGO sector.

1.1.2 The crew received the pre-flight documentation that contained weather observations and forecasts indicating extensive cloud coverage with isolated embedded cumulonimbus clouds over the South China Sea and typhoon Mindulle to the southeast of the Philippines. The PIC estimated from the forecast that the weather would affect the flight for the first four hours.

1.1.3 The PIC was comfortable with the planned route on the Electronic Flight Plan as the route assigned was about 150 nm to 200 nm away from the typhoon.

1.1.4 When the flight crew arrived at the aircraft, the PIC briefed the cabin crew in-charge (CIC) of the expected weather en route, emphasising the first four hours of flight.

1.1.5 Prior to passenger boarding, the PIC also made an announcement over the public address (PA) system to the rest of the cabin crew, as part of a standard check during pre-flight preparations, to inform them of the weather. A 'welcome' announcement made by him after the passengers had boarded also included the forecast weather.

1.1.6 The flight departed normally at about 0105 in the early morning. The weather forecast was substantially correct and the fasten seat belt signs in the cabin were switched on and off several times during the flight and during the meal service.

1.1.7 The operator's standard operating procedures (SOP) require the PIC to make a PA announcement, if possible, whenever the fasten seat belt signs are switched on. If the PIC did not make the announcement, then the cabin crew would do so. The cabin crew also had to walk through the cabin to ensure that the passengers' seat belts were fastened, infants were securely strapped in using infant seat belts, monitor passengers who were in the toilets and who may need assistance and all galley equipment securely stowed as required.

1.1.8 As this was a night flight and due to the constant occasional light turbulence, the PIC decided to leave the fasten seat belt signs on after the meal service. This was for the comfort of the passengers as he did not want the passengers' rest to be interrupted by the chime and PA

announcement that accompanied the switching on and off of the fasten seat belt signs.

1.1.9 After about 3 hours into the flight (around 0400), the aircraft encountered moderate turbulence near waypoint ARESI.

1.1.10 About 40 nautical miles (nm) prior to the onset of turbulence the aircraft was flying on airway L625. The flight crew saw weather cells associated with clouds and moisture on their weather radar and obtained a clearance from Ho Chi Minh Control to deviate by 30nm to the right of airway L625. While the aircraft was abeam waypoint ARESI, the control was passed to Manila Control, which was aware of this deviation off track.

1.1.11 About two to three minutes prior to the turbulence event the aircraft entered a high layer cloud and visibility was reduced. While at 25nm right of airway L625 the PF noticed two weather cells about 40nm apart, depicted with a clear area between them on his weather radar. A left turn was initiated to navigate through the clear area between the two cells which would also bring the aircraft back to the flight planned airway L625.

1.1.12 During this time the PF felt it prudent to get the crew seated. The PF recalled the fasten seat belt switch was already at the ON position when he proceeded to cycle the switch, i.e. to turn the switch to OFF and then ON again. (This should create a double chime in the cabin to signal to the cabin crew to sit down.) The PF could not recall how many times he cycled the switch and the number of chimes that had been generated. The flight crew did not make any announcement to alert the cabin crew regarding the possible turbulence. The four cabin crew members interviewed recalled hearing only one chime. The CIC did not contact the PIC for any further instructions.

1.1.13 According to the PF, about 30 seconds after he had operated the fasten seat belt switch the aircraft encountered moderate to severe turbulence which lasted about 10 to 15 seconds. The turbulence included two abrupt vertical movements of the aircraft with no significant deviation from the assigned altitude.

1.1.14 The flight data recorder (FDR) data show the aircraft experienced a maximum vertical G of +1.75 and a minimum of -0.17. The time between the maximum and minimum displacement was about 1 second.

1.1.15 When the aircraft was no longer experiencing turbulence the PF asked the CIC through the intercom system about the condition of the passengers and cabin crew. After checking with all stations the CIC informed the PF that one of the crew members, a Leading Steward (LS), at the rear of the aircraft was injured.

1.1.16 The injured crew member was found on the aft galley floor bleeding from a cut above the left eye. According to the injured crew member, just prior to the turbulence encounter he heard a single chime which suggested that the fasten seat belt signs had come on. He then instructed two other cabin crew members working with him in the aft galley to check the cabin,

while he proceeded to stow a duty free merchandise cart. He added that he had just stowed the cart when the turbulence was encountered.

1.1.17 The injured crew member was moved to the crew seat at Door 4R where first aid was administered. A page for a doctor was made over the passenger address (PA) system. The crew's hands were noticed to have swollen and a cold compress was applied.

1.1.18 The onset of the turbulence was too sudden for the injured crew member to grab hold of the handholds in the galley. He could not remember how he sustained his injuries. He did recall that he was airborne, but could not recollect how he had injured his head or how he had landed to injure his wrists.

1.1.19 When the aircraft was clear of weather the PIC went to the rear of the cabin to speak to the CIC as well as the injured crew member. The CIC recommended a diversion to land as soon as possible due to the nature of the injuries. The PIC checked with the injured crew member whether he would need to divert to seek medical treatment. The injured crew member chose to let the flight continue to Nagoya. Nevertheless, the PIC assured him that if he needed to seek medical treatment at any time they would divert to either Manila or Taipei.

1.1.20 Subsequently, a doctor and a nurse responding to the page earlier assessed the injured crew member as able to continue to Nagoya.

1.2 Injuries to persons

Injuries	Crew	Passengers	Others
Fatal	Nil	Nil	Nil
Serious	1	Nil	Nil
Minor	Nil	Nil	Nil
None	11	213	Nil

1.3 Damage to aircraft

1.3.1 There was no damage to aircraft.

1.4 Other damage

1.4.1 Nil

1.5 Personnel information

1.5.1 Pilot-in-command

Age	:	47 years (Male)
Licence	:	Airline Transport Pilot's Licence, issued by the Civil Aviation Authority of Singapore.
Aircraft rating	:	B777
Licence expiry date	:	31 December 2004
Total flying experience	:	16,700 hours
Flying experience on type	:	1,800 hours
Last Base Check date	:	02 March 2004
Last Line Check	:	02 April 2004
Last Instrument rating date	:	02 March 2004
Last medical check	:	10 June 2004
Medical certificate expiry	:	31 December 2004
Flight time (Prior 24 hrs)	:	0
Flight time (Last 30 days)	:	69 hrs
Flight time (Last 90 days)	:	230 hrs

1.5.2 Co-pilot

Age	:	27 years (Male)
Licence	:	Commercial Pilots License, issued by the Civil Aviation Authority of Singapore.
Aircraft rating	:	B777
Licence expiry date	:	31 December 2004
Total flying experience	:	1,500 hours
Flying experience on type	:	1,260 hours
Last base check date	:	16 June 2004
Last Line Check	:	10 May 2004
Last instrument rating date	:	16 June 2004
Last medical check	:	31 December 2003
Medical certificate expiry	:	31 December 2004
Flight time (Prior 24 hrs)	:	0
Flight time (Last 30 days)	:	80 hrs
Flight time (Last 90 days)	:	208 hrs

1.6 Aircraft information

1.6.1 Airworthiness of Aircraft

1.6.1.1 The aircraft was serviceable and had a valid certificate of airworthiness. From the recent aircraft records, there was no report of cabin passenger address system or cabin annunciation system defects.

1.6.2 Fasten seat belt switch

1.6.2.1 The fasten seat belt switch is a rotary switch located on the overhead panel of the B777 cockpit. The switch has three selections: OFF, AUTO, and ON. The AUTO selection turns the fasten seat belt signs on from ground level to 10,300 ft above ground level (AGL) and automatically switches the signs off when the aircraft attains an altitude above 10,300ft. The OFF selection would turn the fasten seat belt signs off. The ON selection would turn the fasten seat belt signs on.

1.6.3 Fasten seat belt signs

1.6.3.1 The B777 aircraft cabin is fitted with fasten seat belt signs throughout the cabin. The signs illuminate whenever the fasten seat belt switch is in the ON or AUTO selection (aircraft below 10,300 ft), and extinguish whenever the fasten seat belt switch is in the OFF or AUTO selection (aircraft above 10,300 ft). An associated chime will be heard in the cabin whenever the signs are illuminated or extinguished.

1.6.4 Fasten seat belt switch operation

1.6.4.1 In a test on another B777-200 aircraft owned by the operator, when the fasten seat belt switch was turned from the ON position to OFF and after a short pause, to the ON position again, the fasten seat belt signs extinguished and then came on again, accompanied by two chimes. However, when the switch was operated fast (less than 2 seconds), the fasten seat belt signs extinguished and illuminated again, but only one chime was heard.

1.6.4.2 A similar test was carried out on a B777 simulator owned by the operator. The simulator was brought to an altitude of 15,000 ft at which the seat belt sign would be automatically switched off with the switch left in AUTO position. Cycling the fasten seat belt switch from ON to OFF and back to ON again with a short pause at OFF position produced two chimes. When the switch was cycled without a pause, only a single chime was produced.

1.7 Meteorological information

1.7.1 The synoptic chart and satellite picture for the route showed that the estimated first four hours en route had extensive cloud coverage. According to the flight crew, the aircraft was frequently in light turbulence until the turbulence event occurred. At the time of the moderate turbulence encounter, the aircraft was in a high layer cloud manoeuvring between two cumulonimbus cells 40nm apart.

1.8 Aids to navigation

1.8.1 All aircraft systems were operating normally including the weather radar.

1.9 Flight recorders

1.9.1 The aircraft was equipped with a Honeywell solid-state flight data recorder (SSFDR) part number 980-4700-033 and serial number 0387. The SSFDR was removed from the aircraft and successfully read out.

1.9.2 The cockpit voice recorder (CVR) was not removed as the event occurred more than two hours prior to landing and any information pertaining to the turbulence encounter had been overwritten.

1.10 Communications

1.10.1 According to the flight crew, radio transmissions in the Flight Information Region were heavier than normal due to the many requests from other aircraft for diversions due to weather. However, the ATC communication with the aircraft did not present any significant problems with regard to the turbulence event.

1.11 Aerodrome information

1.11.1 Not Applicable.

1.12 Wreckage and impact information

1.12.1 Not Applicable.

1.13 Medical and pathological information

1.13.1 The injured crew member suffered two fractured wrists, a cut above the left eye, and a hair line fracture of the skull above the left eye.

1.14 Fire

1.14.1 Not Applicable

1.15 Survival aspects

1.15.1 This was a survivable incident.

1.16 Tests and research

1.16.1 Nil

1.17 Organisational and management information

1.17.1 Nil

1.18 Additional information

1.18.1 Operator's standard operating procedures

1.18.1.1 Page 02-00-45 of the operator's Safety and Emergency Procedures (SEP) Manual, which addresses light turbulence where cabin services may continue, requires the following:

(a) PIC should make an announcement to alert the cabin crew of impending turbulence and to reassure the passengers.

(b) The cabin crew must take the following actions when the fasten seat belt sign is switched on:

- visually check all passengers' seat belts are fastened;
- monitor passengers who are in the toilets and who may need assistance;
- inform passengers with infants that the infants must be held in arms with infant seat belt fastened or infants in child safety seats must be securely strapped in; and
- ensure all galley equipment is stowed and secured as required.

(c) A 'Note' under cabin crew actions states that if the turbulence sets in suddenly, and the seat belt sign is switched on by the flight crew without any announcement by the PIC, the cabin crew will have to make an announcement to remind the passengers to return to their seats and fasten seat belts before attending to all the above actions.

1.18.1.2 Page 02-00-46 of the SEP Manual, which covers the situation of sudden and unexpected turbulence or where the level of turbulence has increased to the extent that services have to be suspended and crew strapped in, requires the following:

(a) If the turbulence is such that cabin service must cease and the cabin crew should be seated, the PIC shall advise the cabin crew or make an announcement to that effect.

(b) If there is no time for announcement, the flight crew are required to cycle the fasten seat belt switch from OFF or AUTO to ON and OFF and ON again to indicate that cabin service must cease and cabin crew must be seated, and the cabin crew will then make the announcement to remind the passengers to return to their seats and fasten seat belts. The cabin crew are also referred to the Note in page 02-00-45 which requires them to go through the list of actions stated in paragraph 1.18.1.1(b).

(c) The CIC should contact the PIC for further instructions.

1.18.1.3 Pages 02-00-47 and -48 of the SEP Manual contain supplementary information that provides common definitions of the different levels of turbulence and expands on the possible actions.

Turbulence Intensity	PIC Actions	Cabin Crew Actions
Light	• Make assessment to activate Fasten Seat Belt signs.	• Verify passenger compliance with seat belt sign. • Verify infant / children are secure in approved seat. • Secure unattended carts, cabin and service items. • Continue service with caution.
Moderate	• Switch on Fasten Seat Belt sign. • Instruct passengers to fasten seat belt through PA. • Communicate with cabin crew to determine service restrictions.	• Discontinue service and communicate with PIC. • Verify passenger seat belt compliance if conditions permit. • Secure cabin and service items, angle and set cart brake. • Verify lavatories unoccupied, condition permitting. • Sit down in nearest passenger seat or jump seat; if seat unavailable, sit on floor and hold on.
Severe	• Switch on Fasten Seat Belt sign. • If possible make a PA instructing passengers and Cabin Crew to be seated.	• Sit down immediately and secure oneself. • Make a PA or shout commands to passengers to fasten seat belts, secure infants / children. • After turbulence, communicate cabin conditions and injuries to the flight crew.
Extreme	• Switch on Fasten Seat Belt sign. • If possible make a PA instructing passengers and Cabin Crew to be seated.	• Sit down immediately and secure oneself. • Make a PA or shout commands to passengers to fasten seat belts, secure infants / children. • After turbulence, communicate cabin conditions and injuries to the flight crew.

1.18.2 Cabin crew's interpretation of chime signal

1.18.2.1 The verbal instructions provided during SEP training to cabin crew members of the chime accompanying the illumination of the fasten seat belt signs are as follows:

(a) Single chime indicates an impending light turbulence or just a precautionary measure. There is no need for the cabin crew to be seated.

(b) Multiple chimes indicate impending moderate to severe turbulence and there is a need to suspend in-flight service and for the cabin crew to be seated.

1.18.2.2 The use of the multiple chimes as a means to instruct the cabin crew to suspend service and for the cabin crew to be seated is not documented in

any of the operator's documents. According to the operator, the significance of the chime signals is only explained during SEP training.

1.19 Useful or effective investigation techniques

1.19.1 Nil

2 ANALYSIS

It is clear that the Leading Steward's injury was a result of the turbulence experienced. The investigation team's analysis has focused on the following areas:

(a) Chime signal
(b) Standard Operating Procedure

2.1 Chime signal

2.1.1 In anticipation of a turbulence encounter, the PF followed the company's contingency procedure by cycling the fasten seat belt switch in an attempt to create multiple chimes to advise the cabin crew to cease cabin service and be seated. However, the PF had most likely cycled the fasten seat belt switch too quickly and as a result only one chime was generated in the cabin. The flight crew also did not make any announcement. A single chime without a PA announcement was taken by the cabin crew to mean an impending light turbulence or just a precautionary measure. The cabin crew made the normal cabin announcements to the passengers and proceeded with a walk through the cabin to verify passengers' compliance with safety instructions.

2.1.2 The CIC did not contact the PIC for any further instruction, as the single chime without a PA announcement was taken to mean only an impending light turbulence or just a precautionary measure, and in such a case the SOP did not require the CIC to contact the PIC.

2.1.3 The instructions to the cabin crew to suspend cabin service could not be communicated reliably by using chimes, as the number of chimes may not be reliably generated. The use of chimes as a means to convey safety instruction to the cabin crew is not robust.

2.2 Standard operating procedures

2.2.1 The Note in page 02-00-45 of the SEP Manual instructs the cabin crew on what must be done when the fasten seat belt sign is switched on without a PA announcement by the flight crew. Specifically, the cabin crew are to make a PA announcement and then to carry out the set of actions detailed in paragraph 1.18.1.1(b). In a turbulence situation where the cabin service must be discontinued and cabin crew seated and where the flight crew have no time for announcement, then the cabin crew are to make the announcement for passengers to return to seats and fasten seat belts, as required in page 02-00-46 of the SEP Manual. The cabin crew are also referred to the Note in page 02-00-45, which seems to require the cabin crew to carry out the set of actions detailed in paragraph 1.18.1.1(b). However, such actions would appear to be inconsistent with the urgency of the situation which calls for the cabin crew to be strapped in. The operator would need to review its procedures.

2.2.2 While the supplementary information on pages 02-00-47 and -48 of the SEP Manual provides common definitions of the different levels of turbulence, it also expands on the possible actions. The list of possible actions repeats most, but not all, of the actions contained in the SOP in pages 02-00-45 and -46 and thus has an air of comprehensiveness, which might mislead crews into reading the supplementary information on its own and not in conjunction with pages 02-00-45 and -46. This might result in certain actions being omitted. There may be a need for the operator to review and re-organise the information in pages 02-00-45 to 02-00-48.

3 CONCLUSIONS

3.1 Findings

3.1.1 The aircraft was airworthy and there were no pre-existing system deficiencies that could have contributed to the accident.

3.1.2 The PIC could have cycled the fasten seat belt switch too quickly which resulted in only one chime being generated in the cabin. Since he did not make an announcement and with only one chime generated in the cabin, the cabin crew thought that the switching on of the seat belt signs was only for an impending light turbulence or a precautionary measure and reacted accordingly.

3.1.3 The system of using the number of chimes generated by cycling the fasten seat belt switch to advise the cabin crew to cease cabin service and be seated is not robust as the number of chimes may depend on how fast the switch is being operated.

3.1.4 The information in the operator's crew procedures regarding turbulence could be better organised. However, this is not a factor in the occurrence.

4 SAFETY RECOMMENDATIONS AND SAFETY ACTIONS

4.1 The investigation team has in the course of its investigation suggested to the operator to:

(a) review the flight crew procedures of using the chime signal as a means to advise the cabin crew to cease cabin service and be seated and, in the meantime, alert its flight crew that cycling the fasten seat belt switch quickly can result in only one chime being generated, and (AAIB Recommendation R-2005-011)

(b) review its Safety and Emergency Procedures Manual to make the instructions pertaining to the flight and cabin crews' actions in times of impending and sudden turbulence clearer. (AAIB Recommendation R-2005-012)

4.2 The operator has recognised that its procedure of cycling the fasten seat belt switch could not assure that there would be multiple chimes generated to advise the cabin crew to cease cabin service and be seated. The operator has indicated that it had since issued an instruction to alert its flight crews accordingly.

4.3 The operator has also indicated it would review its procedures with regards to turbulence.

4.4 In view of the above, the investigation team has no further specific safety recommendation to make.