FINAL REPORT

Collision between

Garuda Airlines
Boeing 737-300 Registration PK-GGG

and

Singapore Airlines Engineering Company
Maintenance Jeep

on 12 December 2002

AIB/AAI/CAS.001

Ministry of Transport
Singapore

1 June 2004

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 serious incidents to Singapore and foreign civil aircraft in Singapore. The AAIB also participates in overseas investigations of accidents and serious 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."

Preamble

This report on the collision incident on Singapore Changi Airport Taxiway NC3 on 12 December 2002 between a Jakarta-bound Garuda Indonesia B737-300 aircraft, registration PK-GGG, and a maintenance vehicle belonging to the SIA Engineering Company Limited has been prepared basing on the investigation carried out by the Investigator-in-charge of the Air Accident Investigation Bureau of the Ministry of Transport.

Although the incident was not a notifiable incident under the Air Navigation (Investigation of Accident) Regulations, the incident was investigated by the Air Accident Investigation Bureau with a view to drawing safety lessons from the incident. The investigation was carried out in accordance with the Air Navigation (Investigation of Accident) Regulations and Annex 13 to the Convention on International Civil Aviation.

In accordance with the objective of Annex 13, the sole objective of the investigation is the prevention of accidents and incidents. It is not the purpose of the investigation to apportion blame or liability.

AIR ACCIDENT IVNESTIGATION BUREAU OF SINGAPORE
MINISTRY OF TRANSPORT
SINGAPORE

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1 FACTUAL INFORMATION

All times quoted in this report are based on Singapore local time, which is 8 hours ahead of the Coordinated Universal Time (UTC).

1.1 History of the flight

1.1.1 On 12 December 2002, Garuda Indonesia flight GA 833, a Boeing 737-300 aircraft bearing registration mark PK-GGG, was on a scheduled passenger flight from Singapore to Jakarta. It was a "turn-around" flight - it had arrived from Jakarta earlier. The aircraft was parked at Passenger Gate D30 of Changi Airport Terminal 1.

1.1.2 At about 20:35 hours, the co-pilot obtained ATC route clearance for Jakarta. The pushback commenced at 20:39 hours. The crew was given instruction by ATC to "taxi on the greens (and) hold short NC3". The taxi route was Taxiway N3, Taxiway NC3, Taxiway A7 and then to Runway 02R. The aircraft began taxiing out at 20:43 hours for Runway 02R. See chart at **Appendix 1** for the taxiway layout around the Central Apron.

1.1.3 The crew observed that there was slight rain and put on the windshield wipers at low speed. In accordance with the company operations procedures, the crew put on the taxi light, runway turn-off lights, anti-collision lights, position lights, wing lights and logo lights before commencing the taxi.

1.1.4 The pilot-in-command (PIC) did the taxiing. Shortly after the aircraft had started to move under its own power, the PIC tested the brakes and called for the taxi-out checklist. The taxi-out checklist was completed when the aircraft was near Gates D35 or D36. The PIC said that he was taxiing the aircraft at about 12 knots using idle engine speed.

1.1.5 At 20:46 hours, shortly before arriving at Taxiway NC3, ATC instructed GA 833 to continue to follow the green taxiway centre line lights to the holding point of Runway 02R. As instructed, the crew continued the taxi onto Taxiway NC3.

1.1.6 The crew said that when the aircraft turned into Taxiway NC3, they could see the green taxiway centre line lights illuminated all the way to Taxiway A7. According to the crew, the visibility and the existing illumination from the tarmac and apron lightings were adequate for taxiing although it was raining slightly.

1.1.7 Both crew members said that they did not see any ground traffic movement around the taxi and tarmac areas before entering Taxiway NC3. Then, according to the co-pilot, during the taxi manoeuvre on Taxiway NC3, he happened to look out of the side window on the right and saw a vehicle moving faster than the aircraft on the roadway on the right. The vehicle made a left turn to the incident junction of Roadway R5S/

Taxiway NC3 and headed towards the aircraft. He shouted to the PIC to stop the aircraft.

1.1.8 On hearing the co-pilot's shout, the PIC applied brakes to stop the aircraft. At the same instant the PIC felt the aircraft was hit on the right side. The PIC noted the time to be about 20:48 hours. He then set the parking brakes and told the co-pilot to inform ATC that they had been hit by a vehicle.

1.1.9 At about 20:52 hours, the PIC decided to shut down the right engine as a precaution. He then put on the electrical power from the auxiliary power unit (APU). At about 20:55 hours, the PIC shut down the left hand engine.

1.2 Injuries to persons

1.2.1 There were no injuries to the 109 persons (101 passengers and 8 crew members) on board the aircraft. The driver of the vehicle was also not injured.

1.3 Damage to aircraft

1.3.1 The nose gear right hand door was buckled and broken. The nose gear left hand door was damaged through its penetration of the left hand door of the vehicle. (See **Appendix 2**.) There were three shallow dents on the right hand side of the fuselage forward of the nose gear well opening.

1.4 Other damage

1.4.1 The vehicle involved in the collision with the aircraft belonged to the SIA Engineering Company Limited. The roof and the left hand door of the vehicle were crushed by the forward fuselage of the aircraft. The left hand door was also punctured by the nose gear left hand door.

1.4.2 There was a 2-metre long gouge on Taxiway NC3 caused by the rim of the right hand rear wheel of the vehicle when the vehicle was pinned under the aircraft forward fuselage.

1.5 Personnel information

1.5.1

Vehicle Driver:	Male
Age:	29
Apron Driving Licence No:	00002464 issued by the Civil Aviation Authority of Singapore
Date of Expiry of Licence:	26 March 2004

1.5.2 Pilot-in-Command (PIC): Male
Age: 39
Licence: Airline Transport Pilot Licence issued by the Director General of Air Communications, Republic of Indonesia
Aircraft rating: Boeing 737
Licence valid until: 28 April 2003
Medical certificate: 28 October 2002
Total flying experience: 8116:38 hours
Total type experience: 167:14 hours

1.5.3 Co-pilot: Male
Age: 27
Licence: Commercial Pilot Licence issued by the Director General of Air Communications, Republic of Indonesia
Aircraft rating: Boeing 737
Licence valid until: 27 February 2003
Medical certificate: 27 August 2002
Total flying experience: 3911:39 hours
Total type experience: 3711:39 hours

1.6 **Aircraft information**

1.6.1 Aircraft Type: Boeing 737-300
Operator: Garuda Indonesia
Nationality: Indonesia
Aircraft Registration: PK-GGG
Aircraft Serial No: 28731
Aircraft Callsign: GA833
Type of flight: Scheduled Passenger Flight

1.6.2 The aircraft had valid certificate of airworthiness. Maintenance of the aircraft did not have any bearing on this incident.

1.7 **Meteorological information**

1.7.1 The incident occurred at night. According to the Singapore Meteorological Service, there was moderate to heavy rain and the visibility was 3 to 6 km.

1.7.2 The details of the weather report for 20:30 hours and 21:00 hours on 12 December 2002 are as follows respectively:

METAR 121230Z
Wind: 010/05 kt
Visibility: 5000 – TSRA SCT009
Clouds: FEW016CB FEW017TCU BKN160
Temperature: 26/25 C
QNH: 1014 hPa

TEMPO 3000 TSRA SCT010CB
METAR 121300Z
Wind: 050/02 kt
Visibility: 5000 – RA
Clouds: FEW008 FEW017CB SCT050 BKN 150
Temperature: 25/25 C
QNH: 1014 hPa
RETS TEMPO 3000 TSRA SCT010CB

1.8 Aids to navigation

1.8.1 The taxiways at Singapore Changi Airport have yellow centre lines which are supplemented by green centre line lights. These green centre line lights can be selectively controlled by the Ground Controller to guide aircraft to and from runways and aprons.

1.8.2 All navigation aids at Singapore Changi Airport required for aircraft operations, including the green taxiway centre line lighting system described in paragraph 1.8.1 above, were working normally at the time of the incident.

1.9 Communications

1.9.1 The communications between flight GA 833 and the tower have no bearing on this incident.

1.10 Aerodrome information

1.10.1 Rules & Regulations for Airside Driving

1.10.1.1 The CAAS Apron Control/Management Service has published a document titled "Rules & Regulations for Airside Drivers" (10th Edition, 2002). The Foreword of the document explains that the document details the basic safety rules for drivers of vehicles in the airside at Changi Airport and Seletar Airport. It also states that the document should be read in conjunction with other supplementary instructions issued under Apron Notices, which either by nature have not been incorporated or are valid for only a particular period of time.

1.10.2 Crossing of runways, taxiways and taxilanes

1.10.2.1 Paragraph 1.6, titled "Crossing runways", of the "Rules & Regulations for Airside Drivers" (10th Edition, 2002) states, among others, that

"Every vehicle, which is at the point of entering the manoeuvring area, shall stop at the point of entry to the manoeuvring area and the driver

thereof shall first ascertain that there is no aircraft movement before proceeding into the manoeuvring area."

1.10.2.2 Paragraph 1.7, titled "Crossing taxiways/taxilanes using vehicular routes", of the "Rules & Regulations for Airside Drivers" (10th Edition, 2002) states that:

"Before crossing a taxiway on the vehicular route, drivers must reduce speed of their vehicles and ensure that the taxiway or taxilane is clear of any aircraft movement.

In areas where red traffic rights are switched on, all vehicles and pedestrians shall stop at the crossing point to give way to aircraft. In the event that these lights are not on for whatever reason, they may cross the taxiways after ensuring that it is clear of any aircraft movement. This is also applicable to any designated crossings without traffic lights."

1.10.2.3 Paragraph 1.3 of the "Rules & Regulations for Airside Drivers" (10th Edition, 2002) states, among others, that:

"No person or vehicle shall cross a taxiway if an aircraft is taxiing within 200 metres."

1.10.2.4 The "Rules & Regulations for Airside Drivers" (10th Edition, 2002) has the following definitions:

"Manoeuvring area" - That part of an aerodrome used for the take-off, landing and taxiing of aircraft, excluding apron.

"Movement area" - That part of an aerodrome used for the take-off, landing and taxiing of aircraft, consisting of the manoeuvring area and the apron.

"Apron" - A defined area in an aerodrome, intended to accommodate aircraft for purposes of loading or unloading passengers, mail or cargo, fuelling, parking or maintenance.

1.10.3 **The Civil Aviation Authority of Singapore (Aerodrome) Regulations**

1.10.3.1 The following regulations in the CAAS (Aerodrome) Regulations concern vehicular crossing of taxiways:

<u>Regulation 29</u>
Every vehicle which is at the point of entering the manoeuvring area shall stop at the point of entry to the manoeuvring area and the driver thereof shall first ascertain that there is no aircraft movement before proceeding into the manoeuvring area.

Regulation 43
No person or vehicle shall cross the movement area in front of the path of a taxiing aircraft or an aircraft on tow.

Regulation 65(2)
Every driver of a vehicle using the movement area, any road or place in an aerodrome shall conform to the indication given by the traffic sign placed or erected in the movement area, road or place if it is a sign for regulating the movement of traffic or indicating the route to the followed by traffic.

1.10.3.2 The "Rules & Regulations for Airside Drivers" (10th Edition, 2002) includes a list of regulations in the CAAS (Aerodrome) Regulations for which offenders may be offered to have their offences compounded. The regulations mentioned in paragraph 1.10.3.1 are included in the list.

1.10.3.3 The CAAS (Aerodrome) Regulations define "manoeuvring area" and "movement area" as follows:

"Manoeuvring area" means that part of an aerodrome provided for the landing and take-off of aircraft including the surrounding safety zones and the taxiways but excluding any part of the aerodrome set aside for the embarkation and disembarkation of passengers, the loading and unloading of cargo, the maintenance or parking of aircraft.

"Movement area" means that part of an aerodrome provided for the landing and take-off of aircraft on the surface, the embarkation and disembarkation of passengers, the loading and unloading of cargo, the maintenance or parking of aircraft.

1.10.4 Tunnels for vehicular traffic

1.10.4.1 To reduce vehicular traffic crossing the North Cross Taxiways NC1, NC2 and NC3, CAAS constructed two vehicular tunnels to enable vehicles to cross under these taxiways.

1.10.4.2 The Singapore Changi Airport Apron Notice No. 20/00 issued by CAAS on 10 October 2000 (see **Appendix 3**) requires airside vehicles to use the tunnels instead of surface roadways when moving between the terminal buildings and cargo aprons, except such vehicles as mobile steps, joint container pallet loaders, main deck loaders, catering trucks, air-tugs and any vehicles (including load) exceeding 4 metres in height. The Notice explained that the purpose of this arrangement was to minimise vehicular traffic crossing the North Cross Taxiways and also to prevent foreign object from being deposited on the taxiways.

1.10.4.3 The contents of the above mentioned Apron Notice No. 20/00 is not included in the "Rules and Regulations for Airside Drivers" (10th Edition, 2002).

1.10.4.4 Apron Notices are not sent directly by CAAS to the holders of the Airfield Driving Permit holders. They are sent to organisations that operate vehicles on the airside. CAAS includes in the Apron Notices a note requesting the recipient organisations of the Apron Notices to bring the contents of the notices to all their staff concerned. Apron Notice No. 20/00 includes such a note.

1.10.4.5 SIA Engineering Company Limited was a recipient of Apron Notice No. 20/00 and CAAS expected SIA Engineering Company Limited to disseminate the contents of this notice to their staff who hold Airfield Driving Permits. SIA Engineering Company Limited said that regular briefings on apron notices (including Notice No. 20/00) were held for the staff who needed to drive on the airside.

1.10.5 **Ground traffic warning signs**

1.10.5.1 Red triangles on white background are painted on the ground at taxiway/roadway junctions to warn drivers that they are crossing an active taxiway. Such signs were painted on the ground at the incident junction.

1.10.5.2 There were also sign boards at the incident junctions with the words "Caution. Give Way to Aircraft." These sign boards were illuminated on the night of the incident.

1.10.6 **Red traffic light systems**

1.10.6.1 Red traffic lights are installed at certain roadway/taxiway junctions at the Singapore Changi Airport, including the junction where the incident occurred (see **Appendix 4** for the layout and numbering of the traffic lights at the North Cross Taxiways area).

1.10.6.2 The system design was adapted from those used by Traffic Police to sense vehicles on public roads. At each of the roadway/taxiway junctions, at least one red light is located next to the ground traffic warning sign described in paragraph 1.10.5.2 to stop vehicles from entering the taxiway when an aircraft is taxiing on it. Sensor loops are embedded in the taxiway pavement to detect aircraft approaching a roadway/taxiway junction and to switch on the corresponding set of traffic lights automatically. Software timers in the red traffic light control system are also triggered at the same time when the aircraft is detected. These timers will in turn, switch off the activated red traffic lights once the pre-programmed timing has expired.

1.10.6.3 During its design stage, concerns were raised regarding the susceptibility of the sensor loops buried in the taxiway pavement to wear and tear failures and their degrees of sensitivity to different types of aircraft gears, some of which may be made of non-ferromagnetic materials. Notwithstanding these concerns, it was decided that the system would still

be useful as there was no other effective means of controlling or guiding ground traffic at North Cross Taxiway areas. The primary responsibility to look out for aircraft movements within the vicinity of roadway/ taxiway junctions rests with the ground vehicle drivers. The red traffic light system was installed to serve as a supplementary aid to warn drivers of ground vehicles of aircraft approaching a taxiway/roadway crossing.

1.10.6.4 The red traffic light system is currently maintained by CAAS and is checked daily for serviceability. At the time of the incident, the maintenance records showed that the system was functioning normally except for two aircraft sensor loops located at the North Cross Taxiway areas that were known to be unserviceable and were awaiting replacement. These sensor loops were not those located along the route on which GA833 taxied on the night of the incident.

1.10.6.5 Following the incident, the red traffic light system at the incident junction was checked by CAAS' maintenance contractor and CAAS Apron Control and Management Services (ACMS) duty staff and was found to be working properly.

1.10.6.6 However, on three occasions, the investigators observed that the red traffic light system at the North Cross Taxiway areas was not activated when aircraft was approaching vehicular crossings on the North Cross Taxiways.

1.10.6.7 On 13 December 2002 at around 11:00 hours, the red traffic light at the junction of Roadway R3N/North Cross Taxiway NC1 (traffic light No. 6 in Appendix 3) was observed not to have been activated by an Indian Airlines aircraft taxiing from west to east on Taxiway NC1. CAAS' maintenance contractor was called to check the system but could not find any fault with the system.

1.10.6.8 On 10 February 2003 between 16:20 and 17:00 hours, the traffic light at the junction of Roadway R5S/Taxiway NC3 (traffic light No.10[1] in Appendix 3) was observed to be activated when a truck travelling on Taxiway NC3 between the junction of Taxiway N1/Taxiway NC3 and the junction of Taxiway N3/Taxiway NC3. When a Garuda aircraft (registration PK-GWO) taxied from Terminal 1 Central Apron via Taxiway N3 to Taxiway NC3 (i.e. the same taxi route taken by flight GA 833 on the night of the collision incident), the red light did not activate. Several minutes later, when another Garuda aircraft (registration PK-GWK) taxied on the same route, the red light again did not activate.

1.10.6.9 On 13 February 2003 at about 15:40 hours, it was also observed that a Garuda Airbus A330 (registration PK-GPC) taxiing on Taxiway NC3 did

[1] Traffic light No.10 was the one which the driver of the vehicle involved in the collision with aircraft GA 833 said did not have the red light illuminated at the time he drove his vehicle across Taxiway NC3.

not cause traffic light No.10 to activate. About ten minutes later a Royal Brunei Boeing 767-300 taxiing on the same taxiway activated the red light.

1.10.7 **Taxiways**

1.10.7.1 Before the flight, the aircraft was parked at Passenger Gate D30 at Terminal 1. The taxi route from this gate to Runway 02R was via Taxiway N3, Taxiway NC3, Taxiway A7 and then to Runway 02R. The taxiways are equipped with green centre line lights.

1.10.7.2 The taxiway markings, signs and lights were in accordance with the standards of ICAO Annex 14 and were functioning properly on the night of the incident. The green centre line lights on the taxiway were also illuminated and functioning properly on the night of the incident.

1.10.7.3 The section of Taxiway NC3 from the junction of Taxiway N3/Taxiway NC3 to the incident junction is about 110 metres. Taxiway NC3 is 35 metres wide.

1.11 Flight recording

1.11.1 Flight Data Recorder

1.11.1.1 The flight data recorder fitted on the aircraft was a solid state memory flight data recorder with a nominal recording duration of two hours. Particulars of the recorder are as follows:

Part No: 980-4700-001
Serial No: 2301
Manufacturer: AlliedSignal

1.11.1.2 The flight data recording was read out by the Australian Transport Safety Bureau (ATSB). The recorded data were satisfactory and the whole operation from aircraft pushback to the collision was recorded.

1.11.2 Cockpit Voice Recorder

1.11.2.1 The cockpit voice recorder (CVR) fitted on the aircraft was a tape type recorder with a nominal recording duration of 30 minutes. Particulars of the recorder are as follows:

Model No: AV557C
Part No: 980-6005-076
Serial No: 11771
Manufacturer: Sundstrand Data Control

1.11.2.2 Most of the recording of the operation was found to have been recorded over when the left hand engine (and later the auxiliary power unit) was

allowed to continue to operate after the incident. This had caused the CVR to continue to operate and as it had a duration of 30 minutes, any data recorded 30 minutes earlier would be recorded over with new data.

1.12 Wreckage and impact information

1.12.1 Not applicable.

1.13 Medical and pathological information

1.13.1 The two flight crew members were not sent for toxicological tests as their actions were considered to have no bearing on the incident. During the interview with them following the incident they appeared alert and clear in their speech and thought.

1.13.2 The driver was sent for toxicological examination at the Singapore General Hospital on the night of the incident. Medical report showed that the driver was not under influence of drugs or alcohol.

1.14 Fire

1.14.1 There was no fire.

1.15 Survival Aspects

1.15.1 Not applicable.

1.16 Tests and research

1.16.1 In tests conducted following the incident, it was found that a similar vehicle took about 8 seconds to travel from stationary position at the stop point to the point of collision (see Appendix 4). The time taken for the ground vehicle travelling at 30-40 kph and without stopping at the stop sign was measured to be about 6 seconds.

1.16.2 The flight data recorder data showed that the aircraft was moving on Taxiway NC3 at about 16.5 knots (30 kph). The data also showed that the aircraft came to a stop after about 4 seconds from the time the PIC applied brakes. Allowing a brake application reaction time of 1.5 to 2.0 seconds for the PIC after the co-pilot had shouted, it is estimated the aircraft came to a stop in about 6 seconds after the co-pilot had first noticed the vehicle moving towards the aircraft.

1.17 Organisational and management information

1.17.1 Nil.

1.18 Additional information

1.18.1 Interview with driver of vehicle

1.18.1.1 The driver is a licensed aircraft maintenance engineer employed by SIA Engineering Company Limited (SIAEC). He had been on day shift from 08:00 hours to 20:00 hours on 11 December 2002. Following the day shift, he was off duty until about 20:30 hours on 12 December 2002 when he reported for night shift duty. The night shift was supposed to end at 09:30 hours on 13 Dec 02. Prior to his day shift on 11 December 2002, he was on ten days' leave.

1.18.1.2 When he reported for duty, he was initially assigned the following aircraft:

Aircraft	Location	Time
9V-SPA	Gate E1	21:20 hours – arriving flight
9V-SFB	Parking Bay 508	23:05 hours – departure flight
9V-SMK	Gate F34	23:55 hours – departure flight

He said he was comfortable with the timing of the flights assigned to him.

1.18.1.3 He reported for duty at about 20:30 hours. He left the SIAEC line maintenance control room (near Gates D34/D35) at 20:40 hours and proceeded to the cargo aircraft (9V-SFB) at Bay 508 via Roadway R5S northward to get to the other side of the North Cross Taxiways. He said he stopped at the entrance to Taxiway NC3 and the red traffic light (traffic light No. 10 in Appendix 3) was not illuminated. He also said that he did not hear any aircraft approaching. At the junction, he looked right first and then left and saw an aircraft on his left about 400 metres away on Taxiway NC3. He estimated that the aircraft was far away enough, so he proceeded to cross the taxiway. Suddenly, he felt a jolt from the left.

1.18.1.4 He had taken this route instead of the vehicular tunnel because it was of a shorter distance and more convenient. He was going to the cargo aircraft at Bay 508 to put on the electrical power to enable cargo to be loaded. The driver said he was not aware of Apron Notice No. 20/00 that required the vehicle type that he was driving to use the tunnel.

1.18.1.5 In the interview, he said he could not recall the speed of his vehicle at the time of the collision as he was not looking at the speedometer. He estimated that the speed could not be high as he had just accelerated from the stop position at the entrance to Taxiway NC3.

1.18.1.6 He was aware of the procedure for crossing an active taxiway and the caution systems such as caution sign on the roadway, caution panel and

the red traffic light. He said the red traffic light would be on when there was an approaching aircraft. He was also aware that even if the red light was not on, he had to look out and give way to aircraft.

1.18.1.7 He added that there was moderate rain and the wipers were in use. The vehicle windows were not completely wound up, leaving a little gap.

1.18.2 **Interview with crew of GA 833**

1.18.2.1 Interviews were carried out separately with the pilot-in-command (PIC) and the co-pilot following the incident.

1.18.2.2 Both pilots had operated into Changi Airport several times before. The last time the PIC and the co-pilot had operated into Changi Airport was on 4 October 2002 and 30 November 2002 respectively.

1.18.2.3 As the crew was preparing for the departure, they received ATIS Information G.

1.18.2.4 At 20:35 hours, the co-pilot obtained airways clearance to Jakarta from the ATC. The crew noted that there was slight rain when they commenced pushback at 20:39 hours and during the taxi manoeuvre. Before commencing the taxi, the crew had put on the taxi light, runway turn-off lights, anti-collision lights, position lights, wing lights and logo lights. The crew was given instruction by the ATC to “taxi on the greens (and) hold short NC3”.

1.18.2.5 Shortly after starting taxi at 20:42 hours, the PIC called for the taxi-out checklist which was completed when they were at about Gates D35 or D36. The PIC said he taxied the aircraft at about 12 knots using idle engine speeds, although the maximum taxi speed allowed was 25 knots.

1.18.2.6 Shortly before approaching Taxiway NC3, the ATC instructed GA833 to continue to follow the green centre line lights until the holding point of Runway 02R. As the ATC instruction was given just before the aircraft arrived at the holding line for Taxiway NC3, the aircraft continued its taxiing from Taxiway N3 onto Taxiway NC3.

1.18.2.7 After entering Taxiway NC3, the crew noted that green centreline lights were illuminated all the way to Taxiway A7 (about 400 metres away). The visibility and the existing illumination from the tarmac and apron lightings were adequate although it was raining slightly. The crew said that they did not see any ground traffic movement around the taxi and tarmac areas.

1.18.2.8 The co-pilot said that during the taxiing on Taxiway NC3, he happened to look out of the side window on the right and saw a vehicle moving faster than the aircraft on the roadway on the right. The vehicle made a left turn to the incident junction and headed towards the aircraft. He said he

shouted to the PIC to stop when he saw the vehicle moving towards the aircraft.

1.18.2.9 The PIC said that when he heard the co-pilot's shout, he applied brakes. At the same time he felt something hit the aircraft. The PIC noted the time to be 20:48 hours. He then set the parking brakes.

1.18.2.10 At about 20:52 hours, the PIC shut down the right hand engine as a precautionary measure. At about 20:55 hours, he shut down the left hand engine.

1.18.3 **Apron vehicle**

1.18.3.1 The vehicle involved in the incident was a Suzuki Jeep bearing a licence plate number RU 248 D. The aircraft collided with the left side of the vehicle and rolled it over about 45 degrees. The vehicle was pinned under the forward fuselage of the aircraft.

1.18.3.2 The vehicle was sent for inspection to determine if there were any defects that could have contributed to the incident. The vehicle was reported to be in a roadworthy condition.

1.18.4 **Aircraft lights**

1.18.4.1 Following the incident, tests conducted on the aircraft's taxi light, runway turn-off lights, anti-collision lights, position lights, wing lights and logo lights showed the lights to be operating normally.

1.19 **Useful or effective investigation techniques**

1.19.1 Not applicable.

2 ANALYSIS

2.1 General

2.1.1 The investigation team adopted a systemic approach in its analysis of the collision incident. This section analyses the following aspects:

Individual/team actions

- Flight crew's action
- Changi Tower Ground Controller's actions
- Vehicle driver's actions

Ground traffic control

- Red traffic light system
- Singapore Changi Airport Apron Notices
- CAAS Apron Control Rules and Regulations
- Definitions of "manoeuvring area" and "movement area"
- Driver's field of view

2.2 Individual/team actions

2.2.1 Flight crew's action

2.2.1.1 Both pilots had operated into Changi Airport several times before. The last time the PIC and the co-pilot operated into Changi Airport was on 4 October 2002 and 30 November 2002 respectively. The flight crew was familiar with the Central Apron layout.

2.2.1.2 ATC clearance was received and affirmed. The crew was instructed to taxi from Gate D30 to Taxiway NC3 by following the green taxiway centre line lights and to expect to hold just before Taxiway NC3. The pushback was according to procedures. The PIC was taxiing the aircraft.

2.2.1.3 Just before arriving at Taxiway NC3, the flight crew was cleared to proceed to holding point of Runway 02R. At Taxiway NC3 when the co-pilot saw the vehicle on a collision course with the aircraft, he shouted to the PIC. The PIC applied brakes but could not avoid collision with the vehicle. The flight crew notified Changi Ground Control and PT Garuda Indonesia office of the incident and requested for assistance. Passengers disembarked after clearance was given by the commander of the Airport Emergency Service.

2.2.1.4 In summary, the taxiing actions by the crew were in accordance with Changi Airport and PT Garuda Indonesia standard operations procedures.

2.2.2 **Changi Tower Ground Controller's actions**

2.2.2.1 The Ground Controller handled the pushback and taxi of flight GA 833 in accordance with procedures in the Air Traffic Services Manual. The Ground Controller cleared flight GA 833 for pushback. He gave instructions to the flight crew to proceed following the green taxiway centre line lights to the Taxiway NC3 junction and hold. Just before flight GA 833 reached the Taxiway NC3 junction, he instructed flight GA 833 to continue to the holding point of Runway 02R.

2.2.2.2 The actions of the Ground Controller in issuing taxi instructions and selecting the appropriate green taxiway centre line lights were in accordance with the Air Traffic Services Manual.

2.2.3 **Vehicle driver's actions**

2.2.3.1 The flight data recorder data showed that the aircraft was moving on Taxiway NC3 at about 16.5 knots (30 kph) before the incident. The vehicle was noted by the aircraft crew as faster than the aircraft speed. The vehicle's speed is therefore estimated to be at least 30-40 kph.

2.2.3.2 The distance from the stop point (at traffic light No.10) to the point of collision was measured to be 58.5 metres. Tests showed that a similar vehicle took about 8 seconds to travel from stationary position at the stop point to the point of collision, and about 6 seconds if it travelled at 30-40 kph without stopping at the stop point.

2.2.3.3 The aircraft's speed was about 16.5 knots (30 kph). If the vehicle had stopped at the stop point at traffic light No.10, then at the moment when it started to proceed to cross Taxiway NC3, the aircraft would have been about 67 metres from the incident junction. If the vehicle had passed the stop point without stopping and travelled at about 30-40 kph, the aircraft would have been about 50 metres from the incident junction. In both cases, the aircraft should have been within the field of view of the driver at the stop point at traffic light No.10. (See **Appendix 5**.)

2.2.3.4 When the co-pilot saw the vehicle moving towards the aircraft he shouted to the PIC to stop. The PIC applied brakes. The flight data recorder data showed that the aircraft came to a stop about 4 seconds after the PIC applied brakes. Allowing for a PIC reaction time of 1.5 to 2.0 seconds after he heard the co-pilot's shout, it can be estimated that the co-pilot saw the vehicle about 6 seconds before the incident.

2.2.3.5 At 6 seconds before the incident, if the driver of the vehicle had seen the aircraft on Taxiway NC3, he would have sufficient time to slow and stop the vehicle without colliding with the aircraft. It cannot be established whether the driver had stopped the vehicle at the stop point at traffic light No.10 to look out for taxiing aircraft. However, the above speed and space analyses could only lead to the conclusion that the driver had failed

to maintain an adequate look-out for aircraft movement, whether or not he did stop at the stop point.

2.3 Ground traffic control

2.3.1 Red traffic light system

2.3.1.1. The driver of the vehicle said in his interview by the investigators that the red traffic light No. 10 was not illuminated when he stopped before the Taxiway NC3 prior to crossing.

2.3.1.2 The results of the tests conducted by CAAS' maintenance contractor and Apron Control and Management Services after the incident suggest that the system was likely to be in a working condition at the time of the incident. However, it may be difficult to affirm with absolute certainty that the red traffic light No.10 was activated when the ground vehicle crossed into Taxiway NC3 since the sensor loops are known to not be able to detect all aircraft movements.

2.3.1.3 However, whether or not the red traffic light was activated was not a factor in the incident as the driver was fully aware that with or without traffic light, he had a duty to look out for aircraft movement before crossing a taxiway.

2.3.2 Singapore Changi Airport Apron Notices

2.3.2.1 The driver of the vehicle said that he was not aware of Apron Notice No. 20/00 that requires certain types of vehicles to use the roadway tunnels when moving between the terminal buildings and cargo aprons, and that he was not provided with a copy of the Notice.

2.3.2.2 On the other hand, SIA Engineering Company Limited said that regular briefings on Apron Notices (including Notice No. 20/00) were held for their staff and that these Notices were also enlarged and posted on notice boards.

2.3.2.3 Apron Notices are sent directly by the CAAS to organisations that operate vehicles on the airside. Although CAAS requests in the Apron Notices that recipient organisations bring the contents of the notices to all their staff concerned, there is apparently no CAAS enforcement activity to see if the recipient organisations have disseminated the contents of the Apron Notices effectively to their staff or if the Airfield Driving Permit holders are aware of the contents of the Apron Notices. A clear definition of the roles and responsibilities of CAAS, the employers of the Airfield Driving Permit holders and the Airfield Driving Permit holders themselves would help ensure that the contents of Apron Notices are properly disseminated.

2.3.3 CAAS Apron Control Rules and Regulations

2.3.3.1 Regulation 29 of the CAAS (Aerodrome) Regulations requires drivers to stop at the entrance of the manoeuvring area, which specifically includes taxiways under the definition of manoeuvring area. This requirement is captured in paragraph 1.6, titled "Crossing runways", of the CAAS "Rules & Regulations for Airside Drivers" (10th Edition, 2002), in so far as runways are concerned. Although the term "manoeuvring area" is used, the term means runways in the context.

2.3.3.2 In contrast, the requirement of Regulation 29 is not captured in paragraph 1.7, titled "Crossing taxiways/taxilane using vehicular routes", of the CAAS "Rules & Regulations for Airside Drivers" (10th Edition, 2002). This paragraph does not require drivers to stop but only requires that "before crossing a taxiway on the vehicular route, drivers must reduce speed of their vehicles". The inconsistency with Regulation 29 may cause unnecessary confusion to Airfield Driving Permit holders.

2.3.3.3 There is no evidence to suggest that the inconsistency was a factor in the collision incident. However, as it is a good safety practice for vehicle drivers to make an obligatory stop at taxiway crossing points, paragraph 1.7 of the "Rules & Regulations for Airside Drivers" should be aligned with the requirement of Regulation 29.

2.3.4 Definitions of "manoeuvring area" and "movement area"

2.3.4.1 In the CAAS "Rules & Regulations for Airside Drivers" (10th Edition, 2002), movement area is a subset of manoeuvring area; whereas in the CAAS (Aerodrome) Regulations, movement area is not a subset of manoeuvring area as taxiway is specifically included in the definition of manoeuvring area but is not included in the definition of movement area.

2.3.4.2 To the extent that the "Rules & Regulations for Airside Drivers" (10th Edition, 2002) also makes reference to the CAAS (Aerodrome) Regulations, the differences in the definitions may create unnecessary confusion. The definitions should be harmonised.

2.3.5 Driver's field of view

2.3.5.1 The FDR data showed that after it had turned into Taxiway NC3, the aircraft took about 18 seconds to reach the location where the collision occurred. As a vehicle would take only about 8 seconds to move from stationary position from the stop line on Roadway R5S before Taxiway NC3 to the centre of Taxiway NC3, therefore when the driver started to accelerate from the Roadway R5S stop line to cross the taxiway, the aircraft would have already been on Taxiway NC3. If the driver could see, as he had told the investigators, an aircraft 400 metres away, there is no reason he could not have seen GA 833, which was no more than 110

metres away, if he had continued to maintain a look-out for aircraft movement after he had accelerated from the Roadway R5S stop line.

3 FINDINGS AND CONCLUSIONS

3.1 Findings

3.1.1 The incident took place at night in moderate rain.

3.1.2 The flight crew members were properly licensed, qualified, medically fit, and in compliance with flight and duty time regulations.

3.1.3 The driver of the vehicle was properly licensed.

3.1.4 The flight crew members were familiar with the Terminal 1 Central Apron area and the taxiways they travelled on before the collision incident.

3.1.5 The flight crew followed ATC's instructions correctly.

3.1.6 The PIC taxied the aircraft at an appropriate speed for the taxiway condition.

3.1.7 The roadway/taxiway junction where the collision occurred was appropriately marked and had appropriate signs to warn vehicle drivers about to enter the taxiway.

3.1.8 The red traffic lights at the incident junction were checked on the same night after the collision incident by the CAAS' maintenance contractor and Apron Control and Management Services duty staff and were found to be working properly.

3.1.9 The driver of the vehicle was aware of the procedure for crossing an active taxiway and the warning systems. He was aware that even if the red traffic light, if installed, was not activated for whatever reason, he had to look out and give way to aircraft.

3.1.10 The driver of the vehicle stated that he had stopped at the stop line on Roadway R5S before Taxiway NC3, and that he had looked out for aircraft moving on Taxiway NC3 before proceeding to cross the taxiway. Space and time analyses suggest that when he was at the Roadway R5S stop line, the aircraft would have already been taxiing on Taxiway NC3 and would have been within his field of view.

3.1.11 The airworthiness of the aircraft was not a factor in this collision incident.

3.1.12 The vehicle was found to be roadworthy and was not a factor in this collision incident.

3.2 Other Findings

3.2.1 The following are additional findings which are not necessarily or directly relevant to the collision incident:

3.2.1.1 Two vehicular tunnels are provided for vehicular crossing under the North Cross Taxiways NC1, NC2 and NC3. CAAS Apron Notice No. 20/00 dated 10 October 2000 stipulates that certain types of vehicles (including jeeps) are to use the tunnels when moving between the terminal buildings and cargo aprons. Its contents are not included in the "Rules and Regulations for Airside Drivers" (10th Edition, 2002). However, this non-inclusion is not a factor in the collision incident.

3.2.1.2 According to the driver, he was not provided with a copy of Apron Notice No. 20/00 and was not aware that for the type of vehicle he was driving, he had to use the vehicular tunnel. It is not clear whether it is the CAAS, the employer of the Airfield Driving Permit holders or the Airfield Driving Permit holders themselves who are responsible for ensuring that Airfield Driving Permit holders are aware of the contents of the requirements of the Apron Notices. However, this unclear definition of responsibility did not have a direct bearing on the collision incident.

3.2.1.3 The CAAS' "Rules & Regulations for Airside Drivers" (10th Edition, 2002) stipulates that drivers must reduce speed of their vehicles before crossing a taxiway and ensure that the taxiway is clear of any aircraft movement. This is not consistent with Regulation 29 of the Civil Aviation Authority of Singapore (Aerodrome) Regulations which requires every vehicle to stop at the point of entering a taxiway before proceeding to cross the taxiway, in order to ascertain that there is no aircraft movement. This inconsistency is not a factor in the collision incident.

3.2.1.4 The definitions of "manoeuvring area" and "movement area" in the CAAS "Rules and Regulations for Airside Drivers" (10th Edition, 2002) are not consistent with the definitions of these terms in the Civil Aviation Authority of Singapore (Aerodrome) Regulations. However, this inconsistency is not a factor in the collision incident.

3.3 **Conclusion**

3.3.1 The collision was the result of the failure of the driver of the vehicle to maintain an adequate look-out for aircraft movement on Taxiway NC3.

4 SAFETY RECOMMENDATIONS

These safety recommendations are the results of the investigation into the incident and hence should not be read in isolation from other parts of the report, especially the analysis, findings and conclusions.

4.1 CAAS should review its "Rules and Regulations for Airside Drivers" to:

(a) Ensure that its rules are consistent with the Civil Aviation Authority of Singapore (Aerodrome) Regulations. [AAIB Recommendation R-2004-009]

(b) Include in the next edition all relevant CAAS instructions/conditions and Apron Notices with a view to making this document as comprehensive as possible for all Airfield Driving Permit holders. [AAIB Recommendation R-2004-010]

(c) Harmonise the definitions of "manoeuvring area" and "movement area" with those in the Civil Aviation Authority of Singapore (Aerodrome) Regulations. If it is necessary for the differences to be maintained, CAAS should highlight the differences in the "Rules and Regulations for Airside Drivers". [AAIB Recommendation R-2004-011]

4.2 CAAS should review its system of dissemination of Apron Notices with a view to ensuring that all Airfield Driving Permit holders are aware of the contents of the Notices. [AAIB Recommendation R-2004-012]

4.3 CAAS should consider reviewing the reliability of the traffic light systems at the North Cross Taxiways area. [AAIB Recommendation R-2004-013]

4.4 It is recommended that Garuda Indonesia require its flight crews to disconnect their aircraft's flight data and cockpit voice recorders immediately after an aircraft has come to rest following a ground incident or accident. Although this is not a safety deficiency, implementation of the recommendation will ensure that the contents in the recording, which are crucial to subsequent investigations, are preserved. [AAIB Recommendation R-2004-014]

5 SAFETY ACTIONS

5.1 The CAAS has conveyed the following information to the investigation team:

(a) In respect of Recommendations R-2004-009 and -010:

CAAS has updated its “Rules and Regulations for Airside Drivers” in December 2003.

(b) In respect of Recommendation R-2004-011:

CAAS will be amending the definitions of “manoeuvring area” and “movement area” in the Civil Aviation Authority of Singapore (Aerodrome) Regulations.

(c) In respect of Recommendation R-2004-012:

CAAS has reviewed its system of dissemination of Apron Notices with a view to ensuring that all airside drivers are aware of the contents of the Notices. CAAS now posts Apron Notices on the website and also checks on how the employers of the airside drivers disseminate the information in the Apron Notices to their drivers.

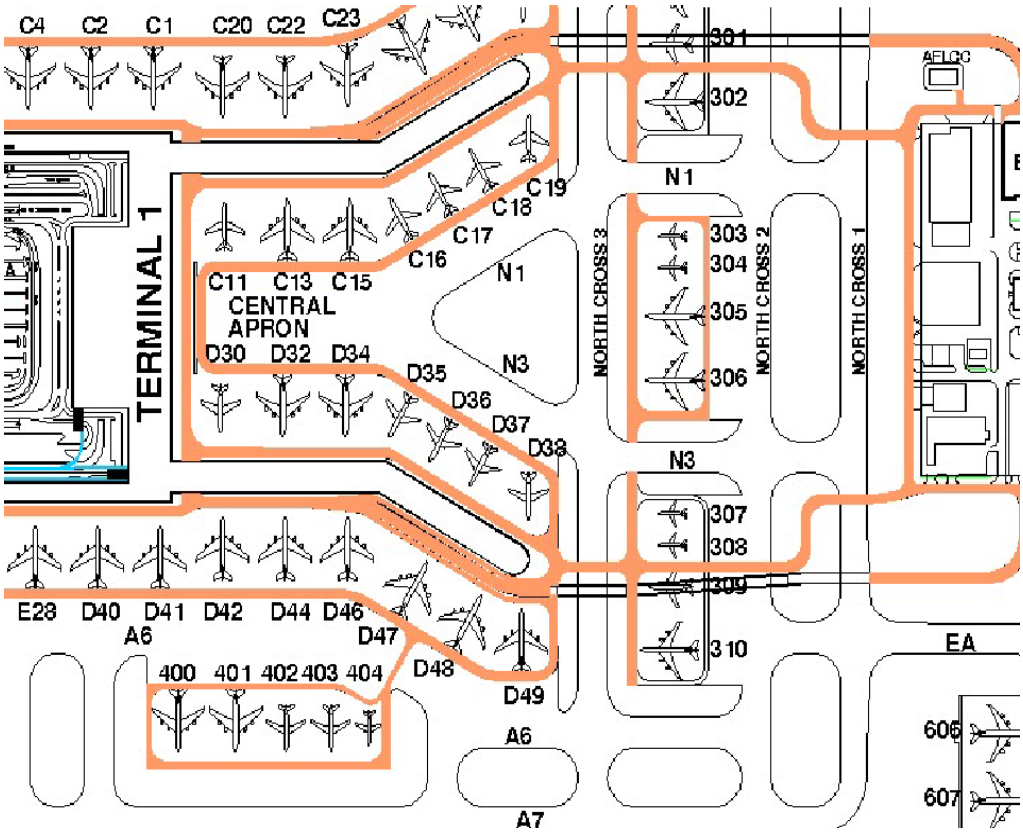
(d) In respect of Recommendation R-2004-013:

CAAS has reviewed the reliability of the traffic light systems at the North Cross Taxiways area of Changi Airport and instituted a number of improvements.

6 **APPENDICES**

Appendix 1

Chart showing layout of taxiways around the Central Apron



Appendix 2

Photographs showing damage to aircraft and vehicle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Appendix 3

CAAS' Singapore Changi Airport Apron Notice No. 20/00

Date	Civil Aviation Authority of Singapore	No.
10 Oct 00	**SINGAPORE CHANGI AIRPORT**	20/00
	APRON NOTICE	

EAST AND WEST TUNNEL ROADWAYS

Airside drivers are reminded that all vehicles except the following are to use the Tunnel Roadways (R1N and R7N) instead of surface roadways (R3N and R5N) when moving between the terminal buildings and cargo aprons: -

(a) Mobile Steps;
(b) Joint Container Pallet Loaders (JCPL);
(c) Main Deck Loaders (MDL);
(d) Catering trucks;
(e) Air-tugs;
(f) Any vehicle (including load) exceeding 4m in height;

2 This is to minimise vehicular traffic crossing the North Cross Taxiways and also to prevent Foreign Object Damage (FOD) from being deposited on the taxiways.

3 Parking or waiting in the tunnel is not allowed. Any breakdown of vehicles in the tunnel must be reported to CAAS Apron Control/Management Service immediately at Tel No. 5412148 or through any of the SOS telephones located in the tunnel.

4 The speed limit for the Tunnel Roadways is 40 kmph. Drivers are advised to keep within the speed limit and exercise caution.

5 All drivers are not to use the Tunnel Roadways whenever the red light on the tunnel gantry is activated.

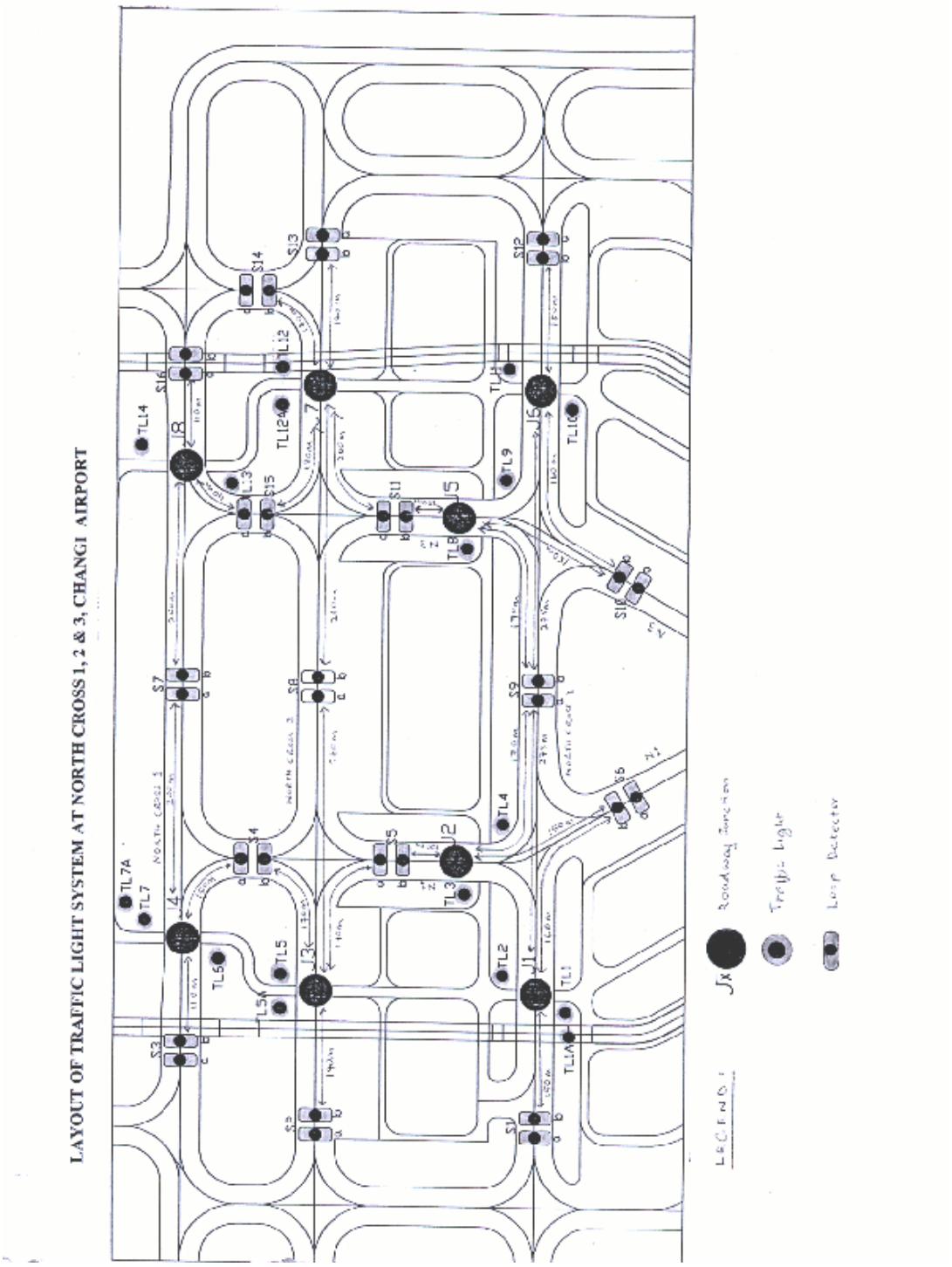
6 Please bring the contents of this notice to all your staff concerned. This notice supercedes the previous notices no. 24/98, 30/98 and 18/99.

K M RAHMANSHA
for DIRECTOR-GENERAL OF CIVIL AVIATION

Apn(3b)/LL:2000tunnel_rdwy

Appendix 4

Chart showing layout and numbering of the traffic lights at the North Cross Taxiways area



Appendix 5

Sketch showing positions of aircraft and vehicle at the incident scene