سلطنة عُمان
وزارة النقل والاتصالات وتقنية المعلومات
Sultanate of Oman
Ministry of Transport, Communications and Information Technology

# Oman Transport Safety Bureau (OTSB)

**Singapore Airlines Boeing 777-312 (ER), SIA306**

**Wake Turbulence over MCT Flight Information Region (FIR) Incident**

# Final Report

**OTSB Case File No: AIFN/001/01/2024**


Make and Model: Boeing 777-312 (ER)
Nationality and Registration Marks: Singaporean, 9V-SWY
Location of the Occurrence: Muscat FIR, Radial 100, Distance 290 nautical miles (nm) from MCT
State of Occurrence: Sultanate of Oman
Date of Occurrence: 13th January 2024, 23:21 UTC
Date of Publication: (03rd October 2024)

## Purpose of the Investigation

The investigation was conducted by the Air Accident Investigation Section of the Oman Transport Safety Bureau (OTSB) pursuant to Civil Aviation Law 76/2019 Chapter 10, and in compliance with the Civil Aviation Regulation CAR-13.011 - Aircraft Accident & Incident Investigation & Reporting Procedures. The investigation was in conformance with the standards and recommended practices in Annex 13 - Aircraft Accident and Incident Investigation to the Convention on International Civil Aviation Organization (ICAO).

The sole objective of the investigation of an accident and incident is to prevent future aircraft accidents and incidents and not to apportion blame or liability.

Oman Transport Safety Bureau issues this Final Report in accordance with the national and international standards, and industry best practice therefore concerned parties are invited to review this report and provide their significant and substantiated comments.

The Final Report will be publicly available at:

http://www.mtcit.gov.om

Oman Transport Safety Bureau

Ministry of Transport Communications and Information Technology

The Sultanate of Oman

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| Abbreviation | Description |
|---|---|
| **°** | Degrees |
| **°C** | Degrees Celsius |
| **AAIS** | Air Accident Investigation Section |
| **AFL** | Actual Flight Level |
| **ATC** | Air Traffic Control |
| **ATCO** | Air Traffic Controller |
| **AWY** | Airway |
| **CAA** | Civil Aviation Authority |
| **C of A** | Certificate of Airworthiness |
| **CBTA** | Competency Based Training and Assessment |
| **CFL** | Cleared Flight Level |
| **CR** | Central Radar |
| **C of R** | Certificate of Registration |
| **CRS** | Certificate of Release to Service |
| **CVR** | Cockpit Voice Recorder |
| **EBT** | Evidence Based Training |
| **EGLL** | London-Heathrow Airport |
| **FIR** | Flight Information Region |
| **FL** | Flight level |
| **FMS** | Flight Management System |
| **FPL** | Flight Plan |
| **FPM** | Feet Per Minute |
| **FT** | Feet |
| **HPA** | Hectopascal |
| **ICAO** | International Civil Aviation Organization |
| **IIC** | Investigator-in-charge |
| **KT** | Knots |
| **LB** | Level Bust |
| **LPC** | Line Proficiency Checks |
| **M** | Metre |
| **MATSOP** | Manual of Air Traffic Standard Operational Procedures |
| **MCT** | Muscat International Airport |
| **METAR** | Meteorological Aerodrome Report |
| **NM** | Nautical Mile |
| **NTSB** | National Transportation Safety Board |
| **OFP** | Over Flight Plan |

| | |
|---|---|
| **OLC** | Operator Line Check |
| **OOMS** | Muscat International Airport |
| **OPC** | Operator Proficiency Checks |
| **OTSB** | Oman Transport Safety Bureau |
| **PF** | Pilot Flying |
| **PM** | Pilot Monitoring |
| **QNH** | Altitude Above Mean Sea Level |
| **RA** | Resolution Advisory |
| **RDR** | Radar |
| **ROC** | Rate of climb |
| **ROD** | Rate of descent |
| **RVSM** | Reduced Vertical Separation Minima |
| **RPA** | Radioactive Protection Advisor |
| **SEP** | Separation |
| **SIA** | Singapore Airlines |
| **SOP** | Standard Operating Procedures |
| **TCAS** | Traffic Collision Avoidance System |
| **TAT** | Total Air Temperature |
| **TSIB** | Transport Safety Investigation Bureau |
| **UTC** | Universal Time Coordinated |
| **VOR** | Very High Frequency Omnidirectional Range Omnidirectional Range |
| **VHF** | Very High Frequency |
| **VWS** | Vertical Winds hear |
| **WPT** | Way-Point |
| **WSSS** | Singapore Changi International Airport |

**Synopsis**

Oman Transport Safety Bureau (OTSB) was notified of the occurrence by the operator through OTSB email on 14th January 2024 at 08:36 UTC and by Sultanate of Oman Civil Aviation Authority (CAA) -Directorate General of Air Navigation (DGAN)- Air Navigation Service Incident Coordination (ANSIC) through OTSB email on 14th January 2024 at 08:36 UTC .The incident happened on 13th January 2024 at 23:12 UTC.

Following the review of the occurrence, the OTSB classified the occurrence as an Incident and the Director of OTSB appointed investigator in charge (IIC) and investigation team to institute and conduct investigation. The following parties were notified:

- State of Occurrence, Sultanate of Oman (CAA)
- State of Operator, and Registry, Singapore (TSIB)
- State of Design and Manufacturer, United States of America (NTSB)
- International Civil Aviation Organization (ICAO)

An investigation team was appointed and investigation was conducted in conformance with the ICAO Annex13, CAR 13 and OTSB Investigation procedures. The Sultanate of Oman is the State of Occurrence. The following parties were involved in the investigation through their appointed accredited representatives and advisers:

- National Transportation Safety Board (NTSB) of United State of America
- Boeing: Organization responsible for type design and final assembly of the aircraft.
- Transport Safety Investigation Bureau (TSIB) of Singapore

This is the Final Report issued on (03rd Oct 2024) and it is published at the below link:

www.mtcit.gov.om

Unless otherwise mentioned, all times in this report are UTC. Local Time in The Sultanate of Oman is UTC plus +4 hours. Photos and figures used in this report were obtained from (‘source’) and (‘adjusted from the original for the sole purpose of improving the clarity of the report). Modifications to images used in this Report are limited to cropping, magnification, file compression, or enhancement of colour, brightness, contrast or insertion of text boxes, arrows or lines.

On 13th January 2024 at 17:10 UTC, Singapore Airlines aircraft with registration marks 9V-SWY, Boeing 777-312-ER departed from Singapore Changi International Airport (WSSS) on an international scheduled flight number SIA306 to London - Heathrow Airport (EGLL). En-route to

London-Heathrow Airport, the aircraft entered Muscat Flight Information Region (FIR) via Way Point (WAP) PARAR (airway N571 PARAR at Flight Level (FL) 320. The flight crew of aircraft SIA306 reported that 2 minutes after passing a reciprocal traffic (Airbus 380) which was at FL330 on the same airway (bidirectional airway), at approximately 23:21 UTC, aircraft SIA306 encountered wake turbulence resulting in rolling the aircraft to the right and climbing momentarily to FL325.

The flight crew of SIA306 reported that the onset was without warning and turbulence was severe momentarily. The flight crew of aircraft SIA306 noticed a pitch up of approximately 10°. The aircraft SIA306 climbed approximately 500 feet above FL320. The flight crew of aircraft SIA306 regained control of the aircraft. The autopilot tripped and manual intervention was required to return the aircraft to original state. The incident lasted less than 2 minutes. Autopilot was re-engaged and descended to FL320. At the time of the incident, wind was steady at 290 degrees/65 kts and no abnormal weather condition was observed by the flight crew of aircraft SIA306. During the time of incident, all cabin crew and passengers were seated, and no injuries were sustained. Thereafter, the aircraft continued to its destination and landed safely without any further incident.

OTSB concludes that the flight crew of aircraft SIA306 experienced a sudden deflection on the control column and trim wheel position due to the wake turbulence generated by the reciprocal traffic aircraft UAE414 (Airbus 380) This resulted in the tripping of the autopilot and subsequent momentary deviation of the cleared vertical flight path by approximately 500ft.

## FACTUAL INFORMATION

### 1.1. History of Flight

1.1.1. On the 13th January 2024 Singapore Airlines aircraft with registration marks 9V-SWY, Boeing 777-312 ER took off from Changi International Airport (WSSS) at 17:10 UTC on an international scheduled flight aircraft SIA306 with intended destination London Heathrow Airport (EGLL).

1.1.2. The aircraft took off from Runway 02C of WSSS with 2 flight crew and 2 relief flight crew.

1.1.3. The flight plan of aircraft SIA306 was to depart from WSSS, then to fly airways over Indonesia, India and then to enter Oman`s airspace through Way Point (WPT) PARAR and to maintain airway (AWY) P307 to point VAXIM and then to follow AWY L430. After that to enter IRAN airspace through WPT MESPO, and then to continue its flight to EGLL.

1.1.4. The flight crew of aircraft SIA306 contacted Muscat Air Traffic Control (ATC) over WPT PARAR at the time 23:12:52. The Air Traffic Controller (ATCO) instructed the flight crew of aircraft SIA306 to maintain FL320 and to continue on flight plan route and to squawk 3526. Meanwhile at the time 23:19:30, aircraft UAE414 (Airbus 380) was on the same AWY P307 at FL330, crossing over (opposite direction) aircraft SIA306 which was at FL320 on AWY P307 which was1000ft below the aircraft UAE414 as per the below ATC radar screen shot (Figure 1)


**Figure 1** :ATC Radar screen shot showing flight levels and details of aircraft SIA306 and aircraft UAE 414

1.1.5. The autopilot of aircraft SIA306 was disconnected, aural warning was heard and the autopilot caption was observed and the flight crew of aircraft SIA306 started to recover from the tripping of the autopilot and subsequent momentary deviation of the cleared vertical flight path of the aircraft by flying the aircraft manually applying roll to the left and descending gently.

1.1.6. As per the statement submitted by PF of aircraft SIA306, reported that while applying the input on control column, it was observed to be mild on back pressure for 5 seconds before gradually lowered to forward pressure to achieve a shallow nose down pitch towards 2.5°.

1.1.7. The highest altitude reached by aircraft SIA306 while in manual flight was FL325. The total duration of the altitude excursion occurred was 28 seconds. The flight crew of aircraft SIA306 turned the seat belt sign “ON” due to the flight path disturbances from the wake turbulence.

1.1.8. At the time of the incident, the cabin crew had already completed passenger service and most passengers were asleep during the incident.

1.1.9. At the time: 23:21:07, the ATCO noticed that aircraft SIA306 had climbed to FL325 on the AWY P307 and observed on the radar screen Level Bust(LB). Immediately the ATCO called the flight crew of aircraft SIA306 to verify the reason of the climb however there was no response from the flight crew of aircraft SIA306.


**Figure 2**: is from ATC radar screen shot showing aircraft SIA306 at flight level 325 with Level Bust( LB )

1.1.10. There was no response from the flight crew of aircraft SIA306 to the ATCO even after ATCO tried to contact the aircraft SIA306 several times from 23:21:07 until 23:23:07. During the attempt by ATCO to establish contact with flight crew of SIA306, the flight crew of aircraft SIA306 were preoccupied by recovering the aircraft from wake turbulence which resulted in the tripping of the autopilot and subsequent momentary deviation of the cleared vertical flight path of the aircraft. The crew of aircraft SIA306 recovered from the situation and the aircraft SIA306 descended and maintained FL320 on AWY P307.

1.1.11. The ATCO established communication on the same frequency 135.6 to the flight crew of 2 aircraft call sign AIC946 and DLH779 to verify if the frequency was readable and both replied and confirmed that the frequency was readable. Then the ATCO tried contacting the crew of aircraft SIA306 on guard frequency 121.5 but there was no reply. The flight crew of aircraft SIA306 responded to the call after the flight crew of aircraft AIC946 relayed the message to the crew of aircraft SIA306 to contact Muscat ATC. At 23:23:44 the flight crew of aircraft SIA306 were able to establish contact with MCT ATCO on frequency 135.6.

1.1.12. The ATCO inquired from the flight crew of aircraft SIA306 for the reason of climbing to FL325 without ATC clearance and not replying to the calls as the ATCO tried contacting aircraft SIA306 for 2 minutes and 38 seconds. The flight crew of aircraft SIA306 advised the ATCO that the aircraft encountered wake turbulence from other traffic passing above and they were recovering aircraft SIA306 from the situation. Also, the ATCO

advised aircraft SIA306 flight crew that there was traffic, aircraft AIC946 on AWY N881 that had crossed WPT SETSI left to right at FL320.

1.1.13. According to the ATC radar screen, the aircraft SIA306 was seen deviating from its altitude and there was a traffic on opposite direction aircraft AIC946 at FL330 with a horizontal separation of 5.72nm to the right of aircraft SIA306 FL320.

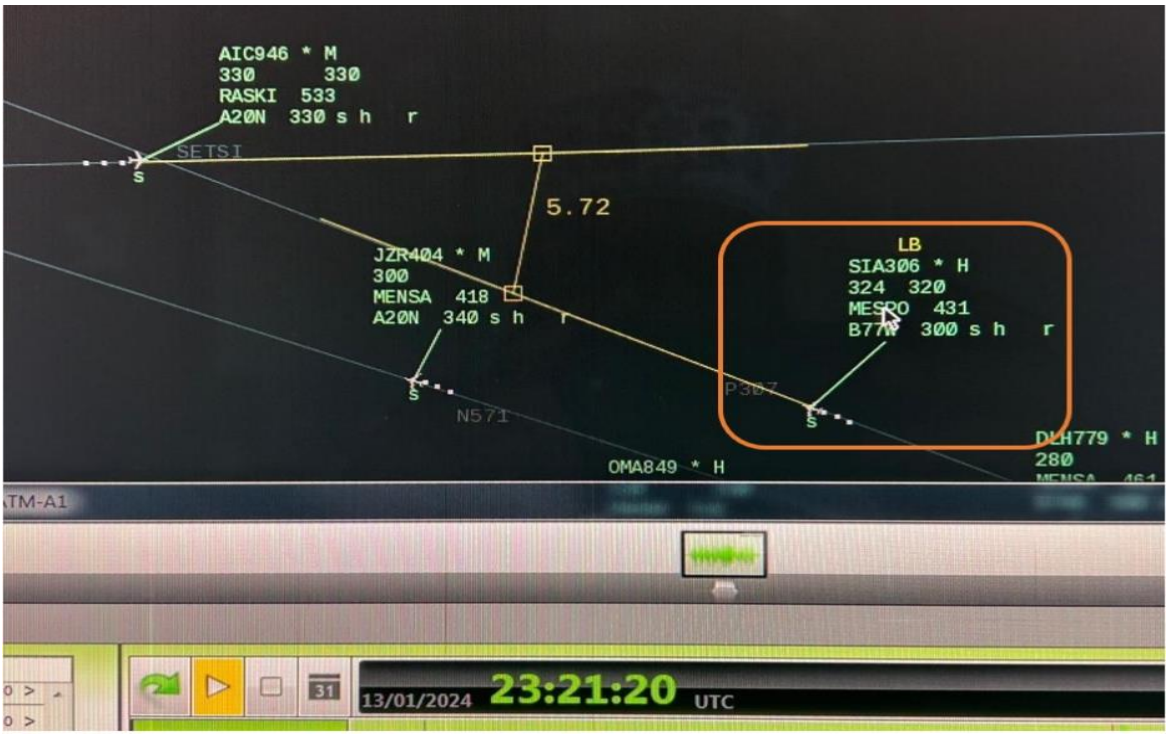


**Figure 3**: shows ATC radar screen shot of aircraft SIA306 during the recovery phase and aircraft AIC946

1.1.14. Following the incident, the cabin crew of aircraft SIA306 reported that sudden turbulence was felt and the seat belt sign came on followed by the Captain`s announcement for the cabin crew to be seated. After the turbulence had stabilized and once the cabin crew were all seated, Cabin In Charge (CIC) and cabin crew walked around the cabin to check on passengers and no passengers nor cabin crew were injured and the PIC was informed.

1.1.15. The aircraft SIA306 continued its flight to destination EGLL and landed safely with no further incident.

## 1.2. Injuries to Persons

| Injuries | Pilot | Crew | Pass. | Total on Board | Other |
|---|---|---|---|---|---|
| Fatal | - | - | - | - | - |
| Serious | - | - | - | - | - |
| Minor | - | - | - | - | - |
| None | 4 | 15 | 244 | **263** | - |
| **Total** | **4** | **15** | **244** | **263** | **-** |

Note: Other means people on ground.

1.2.1. No injuries were reported.

### 1.3. Damage to Aircraft

1.3.1. No damages were reported

### 1.4. Other Damage

1.4.1. No other damages were reported

### 1.5. Personnel Information

1.5.1 Pilot-in-command (Pilot Flying)

| | | | |
|---|---|---|---|
| Nationality | Singaporean | | |
| Licence Type | Airline Transport Pilot Licence | | |
| Licence Valid | Yes | Type Endorsed | Yes |
| Ratings | Instrument rating, Multi-Engine | | |
| OLC/Latest LPC/Latest OPC | 11th January 2024/ 31st December 2023/ 31st December 2023 | | |
| Medical Expiry Date | 30th November 2024 | | |
| Restrictions | None | | |
| Previous Accidents | None | | |

Note: Previous accidents/incidents refer to past accidents/incidents the pilot was involved in, when relevant.

**Flying Experience:**

| | |
|---|---|
| Total Hours | 16852 |
| Total Past 24 Hours | 06:08 |
| Total Past 7 Days | 09:47 |
| Total Past 30 Days | 58:46 |
| Total Past 90 Days | 248:35 |

Flight crew of aircraft SIA306 have successfully accomplished the recurrent training and proficiency checks during the period of 2023 - 2024 as shown in the table below:

The operator has implemented an Evidence-Based Training (EBT) platform for its recurrent training and assessment/check programs, applied using the ICAO-recommended Competency-Based Training and Assessment (CBTA) framework.

The Line Proficiency Checks (LPC) and Operator Proficiency Checks (OPC) have all been conducted by a CAAS Authorized Flight Examiner. The LPC validity is 12 months, and that of OPC is 6 months.
The Operator Line Checks (OLC) were conducted by the Company Appointed Instructors, as authorized by CAAS. The OLC validity is 12 months.

1.5.2 **First officer (Pilot Monitoring)**

| | | | |
|---|---|---|---|
| Nationality | Singaporean | | |
| Licence Type | Multi – Crew Pilot Licence | | |
| Licence Valid | Yes | Type Endorsed | Yes |
| Ratings | Instrument rating, Multi-Engine | | |
| OLC/Latest LPC/Latest | 11th January 2024/ 31st December 2023/ 31st December | | |

| | |
|---|---|
| OPC | 2023 |
| Medical Expiry Date | 31st December 2024 |
| Restrictions | None |
| Previous Accidents | None |

Note: Previous accidents/incidents refer to past accidents/incidents the pilot was involved in, when relevant.

**Flying Experience:**

| | |
|---|---|
| Total Hours | 2465 |
| Total Past 24 Hours | 06:08 |
| Total Past 7 Days | 13:49 |
| Total Past 30 Days | 80:33 |
| Total Past 90 Days | 244:46 |

First Officer of aircraft SIA306 has successfully accomplished the recurrent training and proficiency checks during the period of 2023 - 2024.

The operator has implemented an Evidence-Based Training (EBT) platform for its recurrent training and assessment/check programs, applied using the ICAO- recommended Competency-Based Training and Assessment (CBTA) framework.

The Line Proficiency Checks (LPC) and Operator Proficiency Checks (OPC) have all been conducted by a CAAS Authorized Flight Examiner. The LPC validity is 12 months, and that of OPC is 6 months.

The Operator Line Checks (OLC) were conducted by the Company Appointed Instructors, as authorized by CAAS. The OLC validity is 12 months.

### 1.5.3 Cabin In Charge

| | | | |
|---|---|---|---|
| Nationality | Singaporean | | |
| Licence Type | Cabin Crew | | |
| Licence Valid | Yes | Type Endorsed | Yes |
| Ratings | SEP Programme-A, B and C (incl. CRM, First Aid, Security, Safety Emergency Procedures, Dangerous Goods | | |
| Restrictions | None | | |
| Previous Accidents | None | | |

Note: Previous accidents/incidents refer to past accidents/incidents the pilot was involved in, when relevant.

**Flying Experience:**

| | |
|---|---|
| Total Hours | 4016 |
| Total Past 24 Hours | 06:08 |
| Total Past 7 Days | 24:35 |
| Total Past 90 Days | 91:34 |
| Total Past 90 Days | 282:29 |

## 1.6. Aircraft Information

1.6.1. The Boeing 777 aircraft is a family of long-range wide-body twin-engine jet airliners developed and manufactured by Boeing Commercial Airplanes. It is the world's largest twinjet and has a typical seating capacity for 314 to 451 passengers, with a range of 5,235 to 9,380 nautical miles (9,695 to 17,372 km). Commonly referred to as the "Triple Seven", its distinguishing features include the largest-diameter turbofan engines of any aircraft, six wheels on each main landing gear, fully circular fuselage cross-section, and a blade-shaped tail cone. Developed in consultation with eight major airlines, the 777 was designed to replace older wide-body airliners and bridge the capacity difference between Boeing's 767 and 747. As Boeing's first fly-by-wire airliner, it has computer-mediated controls. It is also the first entirely computer-aided designed commercial aircraft.

**Airframe:**

| | | |
|---|---|---|
| Manufacturer/Model | Boeing 777-312ER | |
| Serial Number | 42238 | |
| Year of Manufacture | 2014 | |
| Total Airframe Hours (At Time of Serious Incidents) | 33,344 FH | |
| Last Inspection (Date & Hours) | 18 Jan 2023 | 28,799 TSN |
| Last Inspection Airframe Cycles (CSN) | 3,609 CSN | |
| Airframe Hours Since Last Inspection | 4,728 FH | |
| Type of inspection preformed | C-Check | |
| CRS Issue Date | 18th Jan 2023 | |
| C of A (Issue Date & Expiry Date) | 16th November 2023 | 23rd November 2024 |
| C of R (Issue Date) | 24th November 2014 | |
| Operating Category | Transport (passenger) | |
| Type of Fuel Used | Jet A / Jet A-1 / No.3 Jet Fuel / RT Fuel / Synthetic Fuels | |
| Previous accidents/incidents/serious incidents | Nil | |

Note: Previous accidents/incidents refer to past accidents/incidents the aircraft was involved in, when relevant to this incident.

**Engine 1:**

| | |
|---|---|
| Manufacturer/Model | GE90-115B |
| Serial Number | 906-434 |
| Part Number | 2115M10G06 |
| Hours Since New | 63,852 FH |
| Hours Since Overhaul | 4,310 FH |
| Hours since last shop visit | 4,310 FH |
| Cycles Available Before Next Shop Visit | 3,450 FC |
| Oil type | Mobil Jet 387 |

**Engine 2:**

| | |
|---|---|
| Manufacturer/Model | GE90-115B |
| Serial Number | 906-282 |
| Part Number | 2115M10G06 |
| Hours Since New | 67,245 FH |
| Hours Since Overhaul | 4,415 FH |
| Hours since last shop visit | 4,415 FH |
| Cycles Available Before Next Shop Visit | 3,435 FC |
| Oil type | Mobil Jet 387 |

## 1.7. Meteorological Information

1.7.1. The weather information below was provided by SIA and obtained from the Meteorological Routine Aerodrome Report (METAR) that was issued by the Meteorological Service Singapore (MSS).

| | | | | | |
|---|---|---|---|---|---|
| Wind Direction | 290° | Wind Speed | 60 kts | Visibility | CAVOK |
| Temperature | -33°C | Cloud Cover | Sky Clear | Cloud Base | Sky Clear |
| Dew Point | None | QNH | 1013 HPA | | |

1.7.2 **Clouds:**

The Satellite image at the time of the occurrence shown below, indicates it was a clear sky and this could indicate that no weather turbulence can be associated at the time of the occurrence.

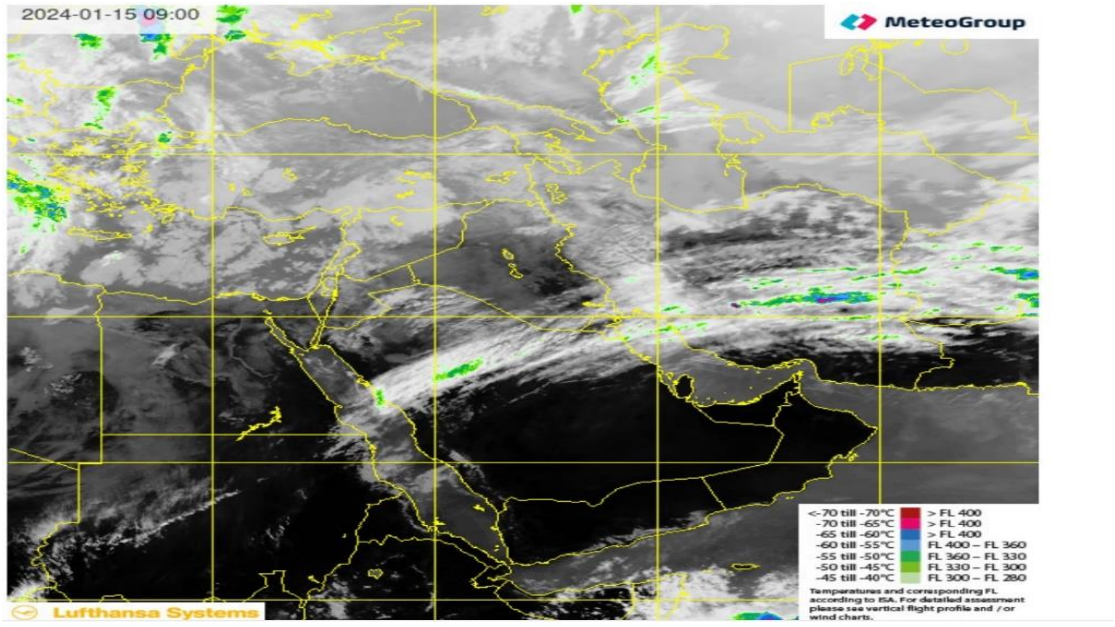


Figure 4: Clouds around the area where the aircraft experienced wake turbulence (Source:SIA)

1.7.3 **Upper winds and Air Temperature (TAT):**

At the time of the occurrence the wind was 290 degrees 60 knots which indicate exactly head wind for the aircraft. The outside air temperature indicates continuous about -33°C during the occurrence.

The weather information below was provided by OMAN CAA - Directorate General Meteorology (DGMET). According to the graph below the wind direction was from 290 degrees and wind speed of 60-70 knots at the location and time of the occurrence. The weather forecast indicates no turbulence at the time of the occurrence.

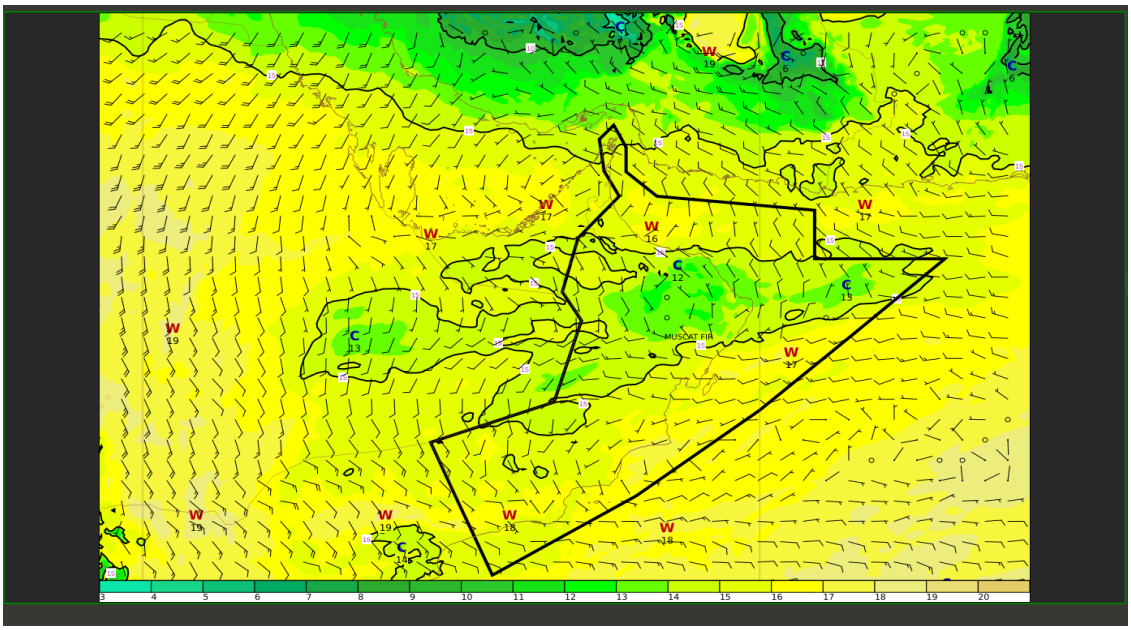


**Figure 5:** Clouds around the area where the aircraft experienced wake turbulence (Oman CAA-DGMET)

## 1.8. Aids to Navigation

1.8.1. The aircraft was equipped with standard navigational equipment as approved by the Civil Aviation Authority of Singapore (CAAS). There were no records indicating that the navigation system was unserviceable prior to the serious incident.

## 1.9. Communication

1.9.1. The aircraft was equipped with a standard communication system as approved by the CAAS. No defects that could render the communication system unserviceable were recorded before the flight.

## 1.10. Aerodrome/Airport Information

1.10.1. Departure Aerodrome:

| | |
|---|---|
| Aerodrome Location | WSSS (Singapore Changi Airport) |
| Aerodrome Status | Licensed Airport |
| Aerodrome GPS coordinates | 1°21’33” North, 103°59’21” East |
| Aerodrome Elevation | 22 ft above mean sea level (AMSL) |

| | | | |
|---|---|---|---|
| Runway Headings/Designations | 02L / 20R | 02C/20C | 02R / 20L |
| Dimensions of Runway Used | 4000 x 60 M | 4000x60 M | 4000 x 60 M |
| Heading of Runway Used | 02C | | |
| Surface of Runway Used | Asphalt | | |
| Approach Facilities | ILS, VOR, RNP, PAPI's, runway lights | | |
| Radio Frequency (Tower/Approach) | 118.60 MHz/ 124.60 MHz | | |
| Category for Rescue Fire Fighting | 10 | | |

1.10.2 Destination Aerodrome:

| | | |
|---|---|---|
| Aerodrome Location | EGLL (London Heathrow Airport) | |
| Aerodrome Status | Licensed Airport | |
| Aerodrome GPS coordinates | 51°28'38" North, 000°27'.41" West | |
| Aerodrome Elevation | 83ft above mean sea level (AMSL) | |
| Runway Headings/Designations | 09L / 27R | 09R / 27L |
| Dimensions of Runway Used | 3902 x 50 m | 3660 x 50 m |
| Heading of Runway Used | 09R | |
| Surface of Runway Used | Asphalt | |
| Approach Facilities | ILS, RNP, PAPI's, runway lights | |
| Radio Frequency (Tower/Approach) | 118.60 MHz/ 124.60 MHz | |
| Category for Rescue Fire Fighting | 10 | |

## 1.11. Flight Recorders

1.11.1. The aircraft was fitted with both the Flight Data Recorder (FDR) and the Cockpit Voice Recorder (CVR) however, at the time of requesting the recording they were already over-written, none were downloaded for this investigation. DFDR had about a 25 hours endurance and the CVR had 2 hours endurance, OTSB relied on Quick Access Recorder (QAR) and Air Traffic Services (ATC) communication records for the investigation.

1.11.2 QAR Data Analysis:

| Time (Z) Aircraft status | Time (Z) Aircraft status |
|---|---|
| 23:20:31 | Vertical G ranges from 0.79G to 1.46G, indicative of sudden onset of turbulence. Autopilot Disconnect warning annunciations. No activation of A/P manual disconnect. Headwind 60kts. |
| 23:20:39 | Pitch increases towards 9.5°. Aircraft rolls left up to 8.7° |
| 23:20:48 | Highest altitude 32400ft. Gradual control column forward pressure applied. |
| 23:20:51 | A/P re-engaged. |
| 23:21:19 | Aircraft returns to within 300ft of cleared altitude |
| 23:21:28 | Aircraft levels off at FL320 |

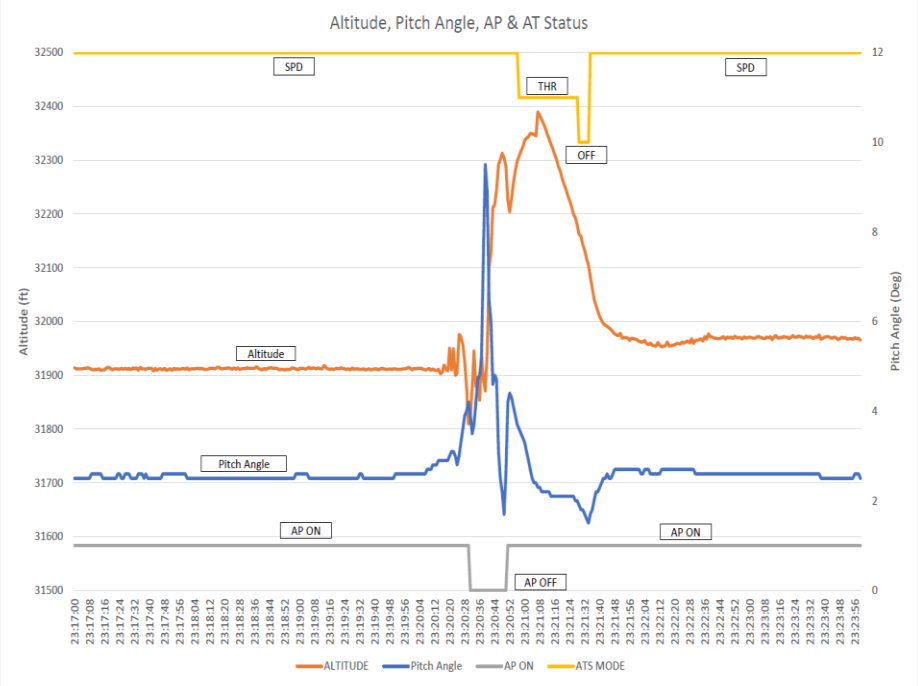


**Figure 6**: showing Altitude, Pitch Angle, AP and AP Status (Source: SIA)

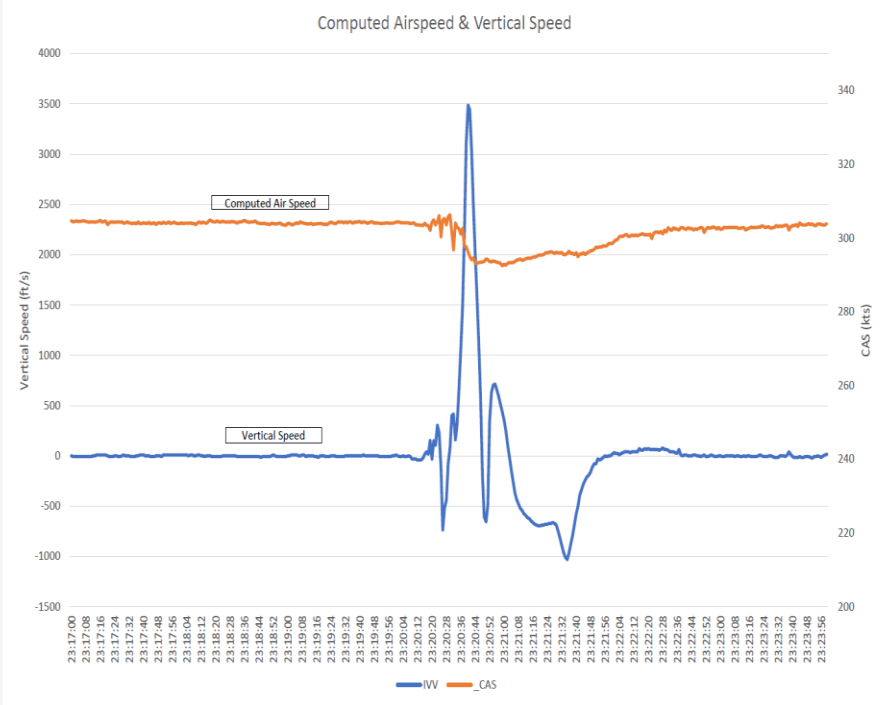


**Figure 7** :showing Computed Airspeed and Vertical Speed (Source:SIA)

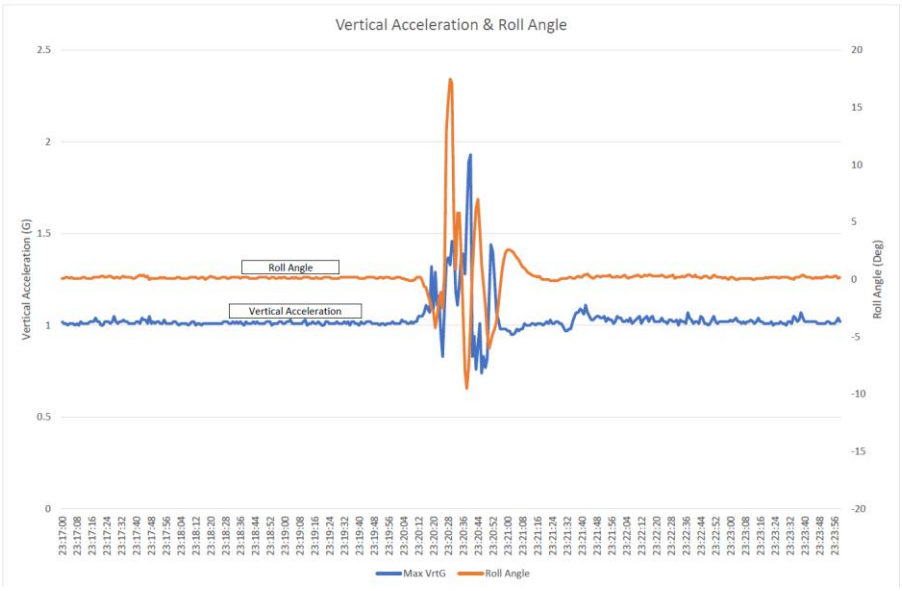


**Figure 8** :showing Vertical Acceleration and Roll Angle (Source:SIA)

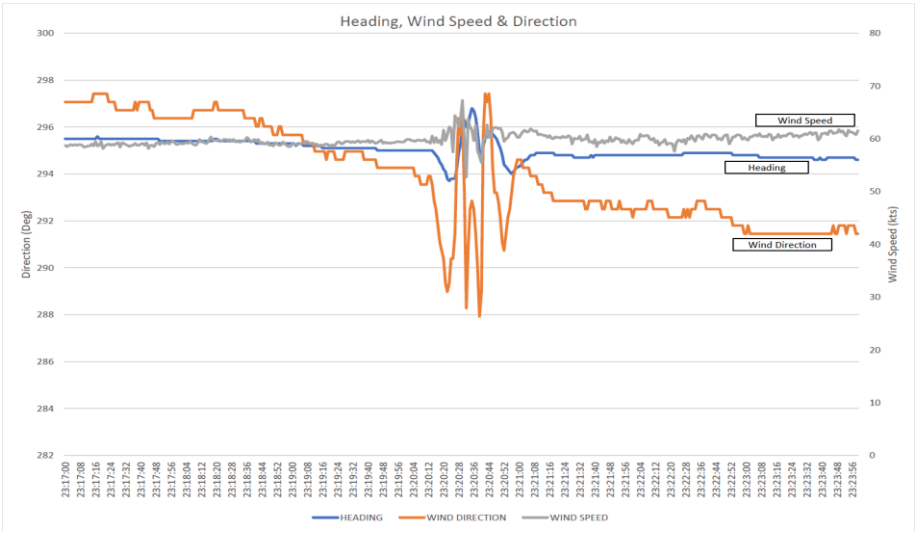


**Figure 9**: showing Heading, Wind Speed and Direction (Source:SIA)

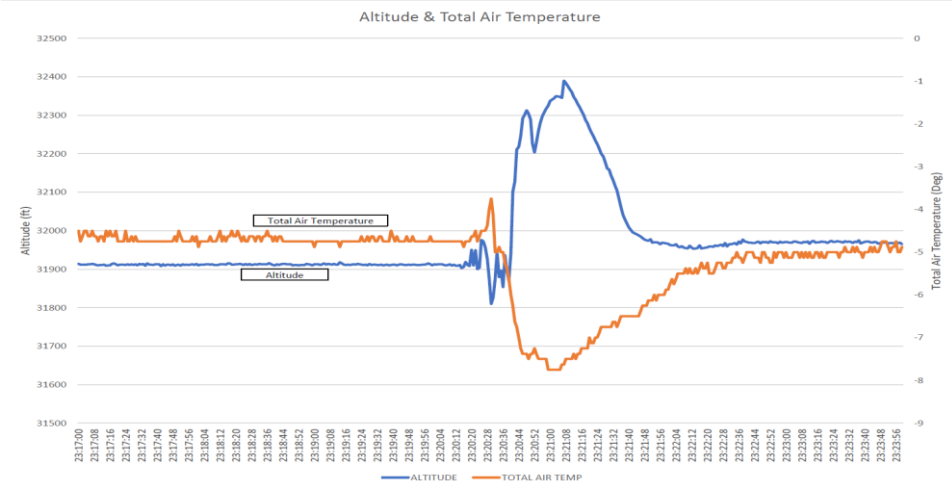


**Figure 10** :showing Altitude and Total Air Temperature (Source:SIA)

## 1.12. Wreckage and Impact Information

1.12.1. Not applicable.

## 1.13. Medical and Pathological Information

1.13.1. Not applicable.

## 1.14. Fire

1.14.1. There was no evidence of pre or post fire.

## 1.15. Survival Aspects

1.15.1. Not applicable.

## 1.16. Tests and Research

1.16.1. Not applicable.

## 1.17. Organizational and Management Information

1.17.1 The flight of SIA306 was scheduled as international passenger flight.

1.17.2 The operator (Singapore Airlines) was issued with an Air Operator Certificate (AOC) by the CAAS, issued on 1st January 2024 with an expiry date of 31st December 2024. The certificate authorized pursuant to Regulation 6 of the Air Navigation (119 - Air Operator Certification) Regulations (as amended) and as delegated by the Authority, the Director-General of CAAS hereby certifies that the Operator is competent to secure the safe operation of the types of aircraft stipulated in the Operations.

1.17.3 Operator's Corporate Flight Safety Management and Procedures Manual
SMS: Safety Reporting

1.17.3.1 REPORTING PROCEDURES

1.17.3.1.1 Reporting of Incidents

(a) Immediate Reporting of Significant or Serious Incidents

The Commander shall notify the local authority and SIAOCC by the quickest means available of any significant or serious incident. In addition, and without delay, the Commander shall notify the local authority and SIAOCC of any emergency situation that resulted in a violation of local rules and/or procedures. These reports to the local authorities should be made primarily through ATC, or if unable, by sending an ACARS report to SIAOCC, who will then communicate with the local authorities. SIAOCC shall also inform CAAS, Transport Safety Investigation Bureau of Singapore and SSQ immediately.

1.17.3.2 INCIDENT REPORTING

1.17.3.2.1 It is company policy that aircraft incidents and accidents on the ground or in flight are reported promptly so that investigation can be carried out to determine the cause and action taken to prevent recurrence.

1.17.3.2.2 Policy

(1) Employees who made the reports will be supported by management. However, intentional breaches of safety that jeopardize operations will need to be addressed appropriately.

1.17.3.3 Digital Flight Data Recorder (DFDR), Cockpit Voice Recorder (CVR)

(1) General

• All SIA's aircraft shall be equipped with a DFDR and CVR that meet the requirements of Aviation Specification 2 by CAAS.

• The recording capacity of the DFDR shall not be less than 25 hours.

• The recording capacity of the CVR shall not be less than 2 hours.

• The recording capacity of the CVR shall not be less than 25 hours for aircraft registered on and after 01 Jan 2022.

• The DFDR and CVR shall not be switched off during flight.

• The MEL shall be referred to for the condition(s) for the dispatch of an aircraft without DFDR or CVR capability.

(2) Removal of CVR and DFDR for Investigation

(i) Accident and Serious Incidents

• The CVR and DFDR are to be preserved for accidents and serious incidents. This may be demanded by the local authorities or by SIAOCC. Flight data provided to accident investigation authorities shall be in electronic format and meet industry specifications.

• The Commander must call for the removal of the CVR and DFDR for investigations if the occurrence is only known to the crew, e.g. in a gross failure to achieve predicted performance during take-off.

• The necessary actions should be taken to ensure that the recordings are not over-written upon completion of the flight. The Commander should annotate in the Technical Log as 'CVR and DFDR removal required for investigation 'and inform SIAOCC and the Station/Cargo Manager when this entry is made. This is to ensure that proper coordination is in place for the preservation of CVR and DFDR.

NOTE: In an accident or serious incident, the host country has the right to demand for the CVR and DFDR. The Station/Cargo Manager must ensure that this requirement is met. In the event of a serious incident or accident, SIA shall retain the flight recorder records, and where possible, the associated flight recorders, in safe custody for a period of 90 days (or such longer period as determined by the Authority) after the accident or serious incident.

1.17.4 According to the reviewed records (OMAN AIP GEN 1.7-2, 5 OCT 23) from ANSIC, Strategic Lateral Offset Procedure (SLOP) was implemented (ENR 1.10-2 item 5) and a suspension of the SLOP was issued through NOTAM A0365/23 on 07/10/2023 and the suspension of the NOTAM expired on 01/01/2024.Another suspension of SLOP was reissued on 17/01/2024 by NOTAM number A0026/24 which was valid till 08/04/2024 and the suspension of the SLOP was again extended till 02/07/2024 by NOTAM number A0179/24.

## 1.18. Additional Information

1.18.1. Wake vortex and wake turbulence − General

WAKE TURBULENCE (Source ICAO DOC 9998 and ICAO DOC 9426)
Note. The term “wake turbulence” is used in this context to describe the effect of the rotating air masses generated behind the wing tips of aircraft, in preference to the term “wake vortex” which describes the nature of the air masses.

In the past there was insufficient agreement on the correlation between wake turbulence research and operational experience to state with an acceptable degree of certainty what weight classifications should be applied to aircraft and what separation should be applied between different kinds of aircraft. Techniques for detecting wake vortices near ground level were available and residence times of vortices detected near ground levels have been recorded in several parts of the world. Operational experience with actual in-flight wake turbulence encounters was well documented.

The recent analysis of wake turbulence data collected by certain States has yielded yet more definitive criteria and the conflict between safety and expedition, between caution and regularity and between separation minima and runway acceptance rate has now been resolved. Much the way aircraft noise is the by product of thrust, aircraft wake turbulence is the by-product of lift. If the harmful effects of noise on communities near aerodromes can produce regulations for its alleviation, so can the potential hazard of wake turbulence.
Wake vortices are present behind every aircraft, but are particularly severe when generated by a large and wide body jet aircraft. These vortices are two counter-rotating cylindrical air masses trailing aft from the aircraft. The vortices are most dangerous to following aircraft during the take-off, initial climb, final approach and landing phases of flight. They tend to drift down and when close to the ground move sideways from the track of the generating aircraft, occasionally rebounding upwards.

According to recent studies, there is turbulence in the wake being generated by the aircraft as well as in the atmosphere. The latter can become just as potentially hazardous in the form of low-level wind shear and clear air turbulence as wake vortices. It is extremely important to make a distinction between these two highly organized, counter-rotating cylindrical air masses trailing aft from aircraft, and the naturally occurring atmospheric turbulence.

**Effects on aircraft**
The three basic effects of wake turbulence on a following aircraft are induced roll, loss of height or rate of climb, and possible structural stress. The greatest danger is the roll induced on the penetrating aircraft to the degree that it exceeds the counter control capability of the aircraft concerned. Should the wake turbulence encounter occur in the approach area, its effect is greater because the following aircraft is in a critical state with regard to speed, thrust, altitude and reaction time.

1.18.2 **Advisory Circular AC-90-23G − Aircraft Wake Turbulence, issued by the Federal Aviation Administration (FAA) of the United States, describes the following:**

“In flight experiments, aircraft have been intentionally flown directly through trailing vortex cores of larger aircraft. It shows that the capability of an aircraft to counteract the roll imposed by the wake vortex primarily depends on the wingspan and counter control responsiveness of the encountering aircraft.”

The Advisory Circular also adds:

“It is more difficult for aircraft with short wingspans (relative to the vortex generating aircraft) to counter the imposed roll induced by vortex flow. Pilots of short-span aircraft, even of the high-performance type, must be especially alert to vortex encounters.”

Figure below: illustrates the effect of wake vortices on a small aircraft following a large aircraft and the expected counter control. For the small aircraft to roll to the left it must have entered the center of the right wing's anticlockwise vortex, or its left wing penetrated the inboard side of the left wing's clockwise vortex, or its right wing penetrated the outboard side of the left wing's clockwise vortex.

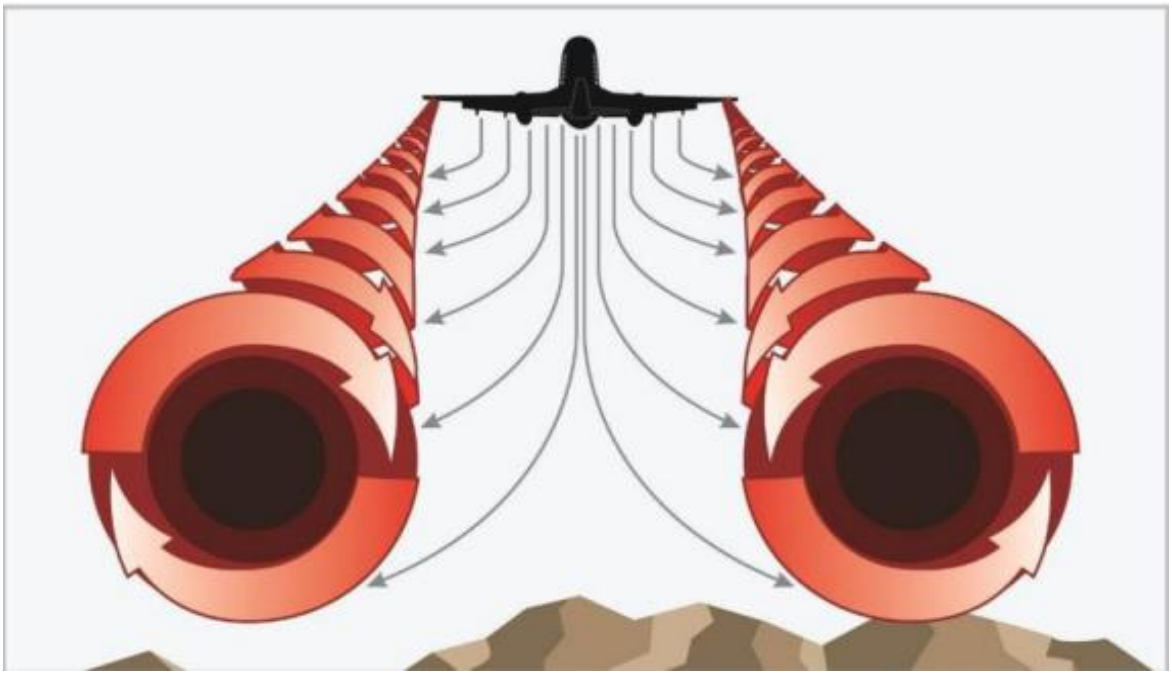

**Figure 11** :above Wake vortex turbulence (Source: FAA)

Vortices typically descend slowly and move outwards when in contact with the ground (figure 12 below). They may persist for up to three minutes and are more likely to persist at lower wind speeds. In particular, in cross-wind conditions, similar to the conditions at the time of the Accident, both vortices may remain at a similar parallel distance when they drift across the flight path, Airbus wake turbulence estimation.

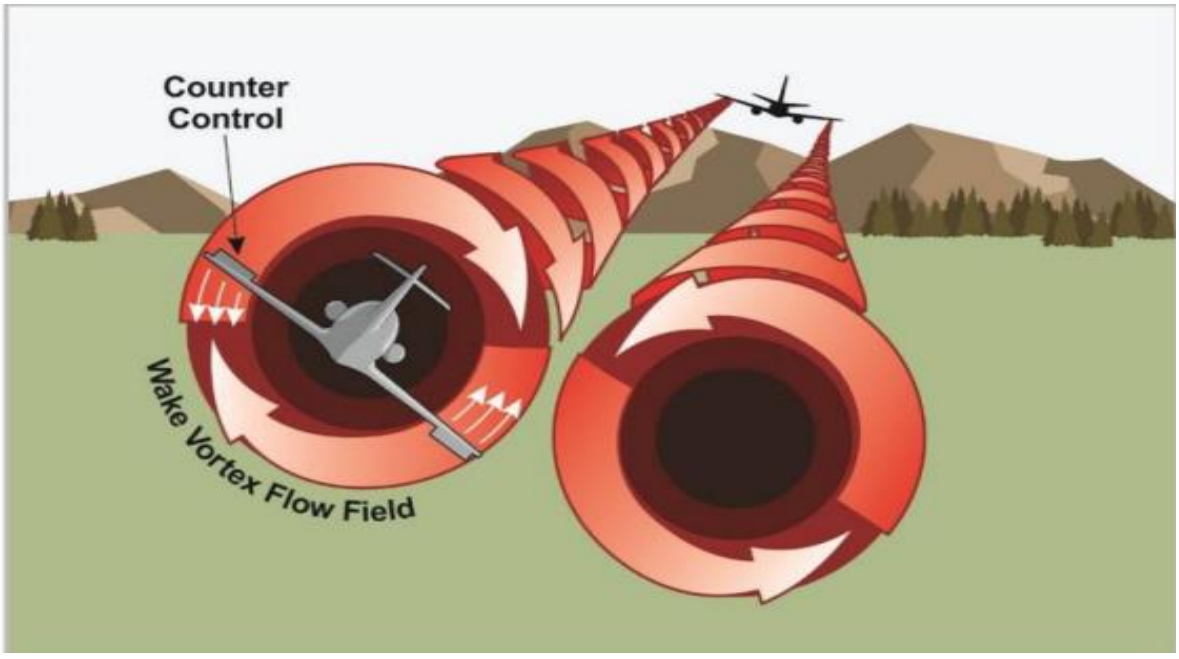


**Figure 12**: showing wake vortices and small aircraft [Source: FAA]

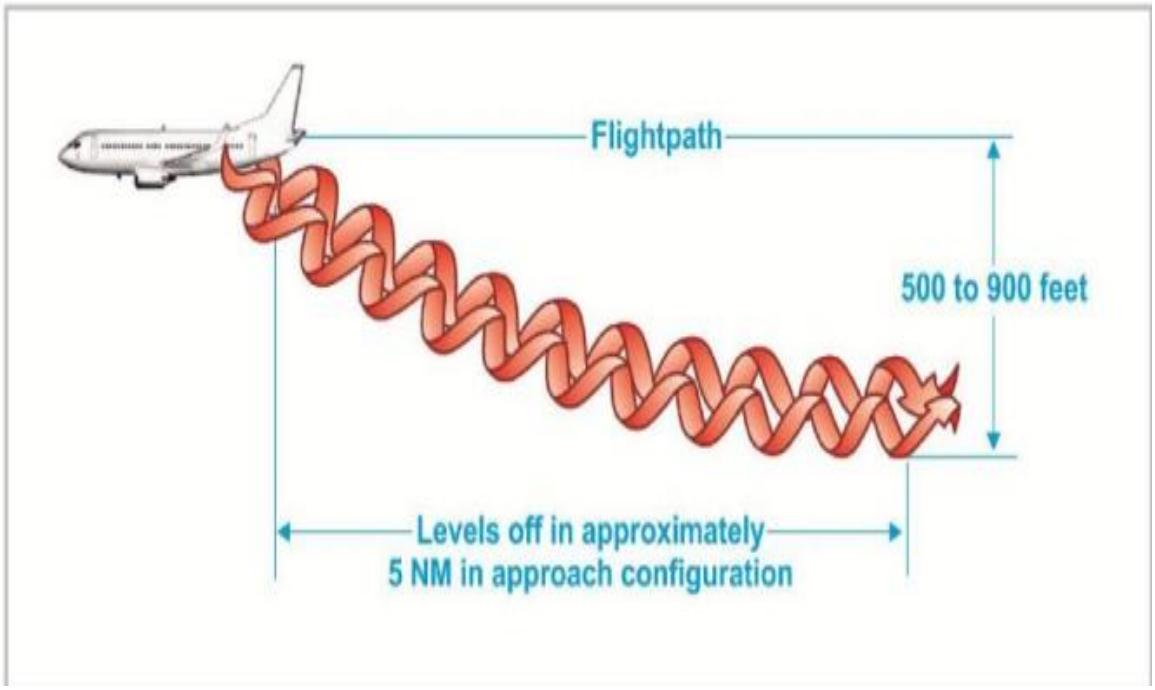


**Figure 13**: showing decent of vortices from large aircraft [Source: FAA]

The risk of encountering wake vortices becomes more probable and severe in the vicinity of airports where aircraft are on approach to or departure from the same runway. The vortices may cause sudden roll movements beyond the flight crew's capability to counteract, leading to a loss of control.

The FAA Advisory Circular advises that: "Pilots should fly at or above the preceding aircraft's flightpath, altering course as necessary, to avoid the area behind and below the generating aircraft."

1.18.3 **ICAO Document 4444 – Air Traffic Management**

The ICAO document Doc 4444 PANS-ATM (16th Edition November 2016) describes a so-called Strategic Lateral Offset Procedure (SLOP).

**STRATEGIC LATERAL OFFSET PROCEDURES (SLOP)**

Note 1.— SLOP are approved procedures that allow aircraft to fly on a parallel track to the right of the center line relative to the direction of flight to mitigate the lateral overlap probability due to increased navigation accuracy and wake turbulence encounters. Unless specified in the separation standard, an aircraft's use of these procedures does not affect the application of prescribed separation standards.

Note 2.— Annex 2, 3.6.2.1.1, requires authorization for the application of strategic lateral offsets from the appropriate ATS authority responsible for the airspace concerned.

1.18.4 Annex 2, 3.6.2 Adherence to current flight plan

An aircraft shall adhere to the current flight plan or the applicable portion of a current flight plan for a controlled flight within the tolerances defined unless an emergency situation arises which necessitates immediate action by the aircraft, in which event as soon as circumstances permit, after such emergency authority is exercised, the appropriate air traffic services unit shall be notified of the action taken and that this action has been taken under emergency authority.

Annex 2, 3.6.5 Communications

An aircraft operated as a controlled flight shall maintain continuous air-ground voice communication watch on the appropriate communication channel of, and establish two-way communication as necessary with, the appropriate air traffic control unit, except as may be prescribed by the appropriate ATS authority in respect of aircraft forming part of aerodrome traffic at a controlled aerodrome.

Unless otherwise authorized by the appropriate ATS authority, or directed by the appropriate air traffic control unit, controlled flights shall, in so far as practicable:
a) when on an established ATS route, operate along the defined center line of that route; or
b) when on any other route, operate directly between the navigation facilities and/or points defining that route.

Implementation of strategic lateral offset procedures shall be coordinated among the States involved.
*Note.— Information concerning the implementation of strategic lateral offset procedures is contained in the* Implementation of Strategic Lateral Offset Procedures *(Circular 354).*

Strategic lateral offsets shall be authorized only in en-route airspace as follows:
a) where the lateral separation minima or spacing between route center lines is 28 km (15 NM) or more, offsets to the right of the center line relative to the direction of flight in tenths of a nautical mile up to a maximum of 3.7 km (2 NM); and

b) where the lateral separation minima or spacing between route center lines is 19 km (10 NM) or more and less than 28 km (15 NM), while one aircraft climbs/descends through the level of another aircraft, offsets to the right of the center line relative to the direction of flight in tenths of a nautical mile up to a maximum of 3.7 km (2 NM); and

c) where the lateral separation minima or spacing between route center lines is 11.1 km (6 NM) or more and less than 28 km (15 NM), offsets to the right of the center line relative to the direction of flight in tenths of a nautical mile up to a maximum of 0.9 km (0.5 NM).

*Note.— Refer to 5.4.1.2.1.6 for lateral separation of aircraft on parallel or non-intersecting tracks or ATS routes.*

The routes or airspace where application of strategic lateral offsets is authorized, and the procedures to be followed by pilots, shall be promulgated in aeronautical information publications (AIPs). In some instances, it may be necessary to impose restrictions on the use of strategic lateral offsets, e.g. where their application may be inappropriate for reasons related to obstacle clearance. Route conformance monitoring systems shall account for the application of SLOP.

The decision to apply a strategic lateral offset shall be the responsibility of the flight crew. The flight crew shall only apply strategic lateral offsets in airspace where such offsets have been authorized by the appropriate ATS authority and when the aircraft is equipped with automatic offset tracking capability.

*Note 1.— Pilots may contact other aircraft on the inter-pilot air-to-air frequency 123.45 MHz to coordinate offsets.*

*Note 2.— The strategic lateral offset procedure has been designed to include offsets to mitigate the effects of wake turbulence of preceding aircraft. If wake turbulence needs to be avoided, an offset to the right and within the limits specified in 16.5.2 may be used.*

*Note 3.— Pilots are not required to inform ATC that a strategic lateral offset is being applied.*

1.18.5 Surveillance Separation Minima (Miscellaneous Operating Instructions)

1.18.5.1The horizontal separation used within Muscat TMA/CTR is 5NM.

1.18.6 **Minimizing the Effect of Wake Turbulence**

1.18.6.1General

The information presented below is not intended to give the impression that ATC may reduce the prescribed wake turbulence separation minima. It is only intended to preclude the need to increase the wake turbulence separation beyond the minima by avoiding, when and where practicable, occasions where conditions are most likely to result in wake turbulence encounters. It follows that the application of the wake turbulence minimum is not an assurance against a wake turbulence encounter; its application only minimizes the hazard.

1.18.6.1Wake turbulence characteristics

1.18.6.1.1 Wake vortices generated by an aircraft in flight are related to the aircraft gross mass, airspeed, configuration and wing span. Vortex characteristics are altered and eventually dominated by interactions between the vortices and the ambient atmosphere. The wind, wind shear, turbulence and atmospheric stability affect the motion and decay of a vortex system. The proximity of the ground significantly affects vortex movement and decay.

1.18.6.1.2 Vortex generation begins on rotation when the nose wheel lifts off the runway and ends when the nose wheel touches down on landing. Vortex strength increases proportionally to weight and is greatest when the generating aircraft is HEAVY, in a clean configuration, and is flying slowly.

1.18.6.1.3 Vortices generally dissipate or break up in one of three ways:

a) over a long period of time, turbulent diffusion can enlarge each wake so that the wakes merge and dissipate;

b) disturbances along the length of the vortices become unstable and sinuous oscillations develop which cause the vortices to touch and link together;

c) a sudden structural change known as vortex breakdown or bursting can abruptly widen the vortex core.

1.18.7 Flight tests have shown that vortices from large aircraft sink at a rate of about 2 to 2.5 m/s (400 to 500 ft/min). They tend to level off at about 275 m (900 ft) below the flight path of the generating aircraft. Wake turbulence strength diminishes with time and distance behind the generating aircraft. Atmospheric turbulence hastens breakup of the vortices. The vortex circulation is outward, upward and around the wing tips when viewed from either ahead of or behind the aircraft. Tests with large aircraft have shown that the vortex flow field, in a plane cutting through the wake at any point downstream, covers an area about two wing spans in width and one wing span in depth, the wing span being that of the generating aircraft (see Figure 14).

It may be helpful to visualize vortex circulation in conjunction with the sink rate shown in Figure 15. The vortices remain spaced, about a wing span apart, and drift with the wind, at

altitudes greater than a wing span from the ground. If persistent wake turbulence is encountered by an aircraft which is being separated by radar from a large aircraft, a slight change of altitude and lateral position (preferably upwind) will provide a flight path clear of the vortices. Aircraft should be operated at or above the flight path of the large aircraft, changing course as necessary to avoid the area behind and below the large aircraft that is generating the wake turbulence.

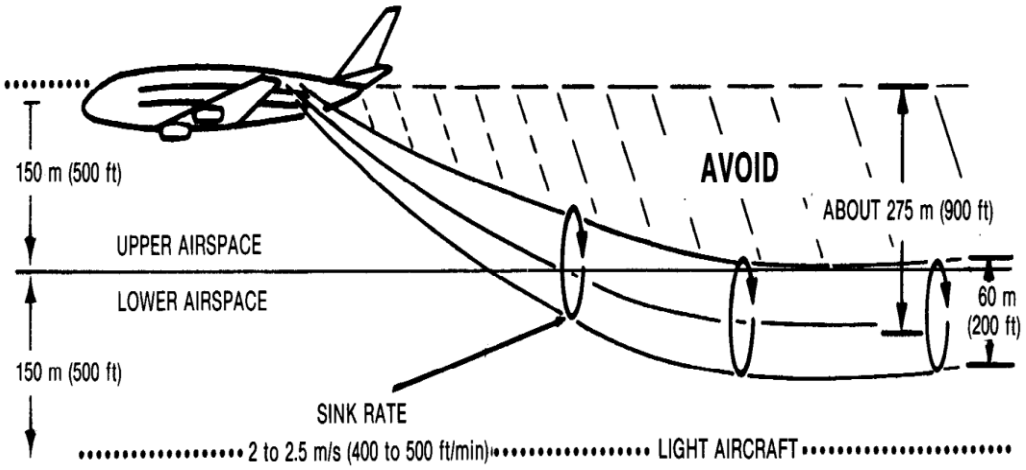


**Figure 14** showing wake turbulence descending into a control zone or ATS route

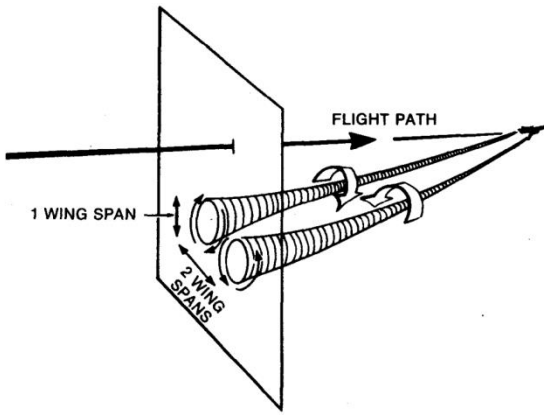


**Figure 15:** the wing span being that of the generating aircraft

### 1.19. Useful or Effective Investigation Techniques

1.19.1. None.

## 2. ANALYSIS

### 2.1 General:

From the available evidence, the following analysis were made with respect to this incident. This shall not be read as apportioning blame or liability to any organization or individual.

### 2.2 Flight operations

2.2.1 Flight crew Qualifications

2.2.1.1 Both the flight crew members of SIA306 were properly licensed and qualified to conduct the flight, their licenses were issued in accordance with CAAS requirements. According to SIAs pilots training program and qualifications of the flight crew, the training covers both the upset

recovery techniques focused primarily on exercises involving pitch excursions and uncommanded rolls which was the case and utilized effectively on this incident.

ATCO instructed the flight crew of SIA306 B777-312ER to maintain FL320 and to continue as per the flight plan route with squawk 3256. Meanwhile, aircraft UAE414 A380 was on the same AWY P307 at FL330 at an altitude separation of 1000 feet above aircraft SIA306. Aircraft UAE414 crossed over aircraft SIA306 which caused the aircraft SIA306 B777-312ER to encounter wake turbulence likely produced by the aircraft UAE414 A380 resulting in the tripping of the autopilot and subsequent momentary deviation of the cleared vertical flight path of the aircraft SIA306.

The flight crew of SIA306 reported that they encountered wake turbulence most probably produced by the aircraft A380 (UAE414) resulting in the aircraft rolling to the right and climbing FL325. Autopilot disconnected at 23:20:30 UTC 1 second later, at 23:20:31 UTC the Autopilot Disconnect Warning Aural Alert sounded and re-engaged at 23:20:50 UTC, the disengagement lasted for 19 seconds. Vertical G force ranging from 0.79G to 1.46G which was an indication of a sudden spike in positive G force as a result of a sudden onset of turbulence. Therefore, due to the tripping of the autopilot and subsequent momentary deviation of the cleared vertical flight path of the aircraft, SIA306 climbed up to FL325, resulting in a level bust of 500ft for 28 seconds.

The Autopilot was disconnected, aural warning was heard and the autopilot caption was observed and the flight crew of aircraft SIA306 started to recover from the tripping of the autopilot and subsequent momentary deviation of the cleared vertical flight path of the aircraft by flying the aircraft manually applying roll to the left and descending gently. The PF of aircraft SIA306 reported that while applying the input on control column, it was observed to be mild on back pressure for 5 seconds before gradually lowered to forward pressure to achieve a shallow nose down pitch towards 2.5°. The situation suggests wake turbulence as a possible cause and, as a result, PF took immediate action to regain control of the aircraft by changing the attitude of the aircraft with control inputs, which was successful.

The flight crew of aircraft SIA306 did not communicate with the ATCO any emergency during the tripping of the autopilot and subsequent momentary deviation of the cleared vertical flight path of the aircraft which is an indication of a sudden and unexpected event which required their full attention.

At the time: 23:21:07, the ATCO noticed that aircraft SIA306 had climbed to FL325 on the AWY P307 and observed on the radar screen Level Bust (LB) of 500ft.Immediately the ATCO called the flight crew of aircraft SIA306 to verify the reason of the climb however there was no response from the flight crew of aircraft SIA306.

During the attempt by ATCO to establish contact with flight crew of SIA306, the crew were preoccupied by recovering the aircraft from wake turbulence, the flight crew of aircraft SIA306 recovered from the tripping of the autopilot and subsequent momentary deviation of the cleared vertical flight path and the aircraft SIA306 descended and maintained FL320 on AWY P307.

The ATCO established communication on the same frequency 135.6 to 2 aircraft call sign AIC946 and DLH779 to verify if the frequency was readable and both replied and confirmed that the frequency was readable. Then the ATCO tried contacting aircraft SIA306 on guard frequency 121.5 but there was no response.

The flight crew of aircraft SIA306 reported that they did not hear nor respond to the ATCO calls when they were contacted. The flight crew of aircraft SIA306 indicated that their focus was on the recovery of the aircraft and safety of the passengers.

2.2.1.2 The flight crew of aircraft SIA306 responded to the call after the flight crew of aircraft AIC946 relayed the message to the crew of aircraft SIA306 to contact Muscat ATC. At 23:23:44 UTC

the flight crew of aircraft SIA306 were able to establish contact with MCT ATCO on frequency 135.6.

The ATCO inquired from the flight crew of aircraft SIA306 for the reason of climbing to FL325 without ATCO's clearance and not replying to the calls as the ATCO tried contacting the flight crew of aircraft SIA306 for 2 minutes and 38 seconds. The flight crew of aircraft SIA306 advised the ATCO that the aircraft encountered wake turbulence from other traffic passing above and they were recovering aircraft SIA306 from the situation. Also, the ATCO advised the flight crew of aircraft SIA306 that there was traffic, aircraft AIC946 on AWY N881 that had crossed WPT SETSI left to right at FL330.

According to the ATC radar screen, the aircraft SIA306 was observed climbing from its flight level and whilst there was a potential conflicting traffic on opposite direction aircraft AIC946 at FL330 with as a horizontal separation of 5.72nm to the right of aircraft SIA306 FL320.

According to the trend's studies and analysis, upsets due to wake vortices encountered at high altitude are relatively rare; however, they can occur very sudden and with little warning. In this occurrence, because of the flight crew of aircraft SIA306 assertiveness they felt and observed the aircraft attitude change and immediately recovered from the uncommanded rolls.

2.2.2 Operational procedures:

In mitigating the recovery of the altitude deviation, the flight crew of aircraft SIA306 followed SLOP procedures as outlined by ICAO.

According to the reviewed records from DGAN, SLOP was implemented (ENR 1.10-2 item 5) and due to the safety issues a suspension of the SLOP was issued through NOTAM A0365/23 on 07/10/2023 and the suspension of the NOTAM expired on 01/01/2024. Another suspension of SLOP was reissued on 17/01/2024 by NOTAM number A0026/24 which was valid till 08/04/2024 and the suspension of the SLOP was again extended till 02/07/2024 by NOTAM number A0179/24. The SLOP was in place on the day of the incident as the NOTAM suspension was not covered during the time of the incident, however DGAN is in the process of implementing a permanent solution.

2.2.3 Weather

An analysis of the upper atmosphere in the vicinity of the occurrence was made by the Singapore Airlines on the flight crew flight plan. No remarkable weather systems were affecting the area at the time, it was a clear sky and that there was no turbulence indications that could be associated with the incident at the time and the area of the incident. Aircraft SIA306 and aircraft UAE414 were flying in clear air above cloud, and neither aircraft encountered significant turbulence in the area immediately prior to, or after the event.

The flight crew of aircraft SIA306 did not observe any cloud on the weather radar system, and or any deviation from flight plan. QAR data indicated that the wind at FL 320 was 290°M which was a head wind to aircraft SIA306 at 60 knots. The outside air temperature indicated continuous fluctuations with a predominant drop of about -36°C to -39°C as the aircraft flight path approached land mass. There were no winds or atmospheric instability however it is likely that due to the headwind on aircraft SIA306, the wake turbulence from aircraft UAE414 A380 dissipated rapidly causing aircraft SIA306 to deviate from its flight level.

2.2.4 Air traffic control

The ATCO held the required licence and medical which was valid at the time of the incident which was issued by Oman CAA. ATCO provided pertinent information to the flight crew in relation to the flight and the track. OTSB determined that the ATCO qualifications were not a factor to the incident.

2.2.5 Communications

At the time: 23:21:07, the ATCO observed on the radar screen that aircraft SIA306 had climbed to FL325 with an LB of 500ft on the AWY P307 and immediately established contact with the flight crew of aircraft SIA306 to verify the reason of the climb however there was no response from aircraft SIA306 flight crew. Seeing that there was no response from aircraft SIA306, ATCO contacted other aircraft in the vicinity and managed to establish contact with the flight crew of aircraft AIC946 by relaying via emergency frequency 121.5 and only after the flight crew of aircraft SIA306 recovered from the tripping of the autopilot and subsequent momentary deviation of the cleared vertical flight path, the flight crew of aircraft SIA306 reported and indicated that the reason why they did not communicate any emergency experienced which was an indication of a sudden and unexpected event that required the flight crew of aircraft SIA306 full attention in an attempt to regain control of the aircraft hence the flight crew of aircraft SIA306 did not hear nor respond to the ATCO when they were contacted.

The flight crew of aircraft SIA306 indicated that their focus was on the recovery of the aircraft and safety of the passengers. At the time of the incident, the ATCO observed that SIA306 had climb above its assigned level. When the ATCO was unable to establish contact with the flight crew of SIA306, they attempted to reach the aircraft on the emergency frequency but were unsuccessful. Subsequently, the ATCO communicated with other nearby aircraft, demonstrating proactiveness on the part of the ATCO. The ATCO also noticed the radar Level Bust (LB) alert, which indicated that SIA306 had ascended above the level input into the ATC system by the ATCO. To provide the required 1000feet vertical separation, SIA306 was to maintain FL320 (a standard westbound level) while aircraft UAE414, which was flying in the opposite direction, was maintaining FL330. There was no action required from the ATCO to separate the two aircraft UAE414 and aircraft SIA306. The effective wake vortices generated by aircraft UAE414 A380 persisted and affected aircraft SIA306 after passing over.

2.2.6 Aids to navigation
The navigational system was found to be serviceable and operated as required at the time of the incident. Therefore, OTSB determined that the navigational aid was not a factor to the incident.

2.2.7 Aerodrome
The incident happened in flight while in cruise, therefore, OTSB determined that the aerodrome was not a factor to the incident.

**2.3 Aircraft Maintenance**

2.3.1 The aircraft was certified and maintained in accordance with existing regulations and approved procedures. There were no pre-existing faults or conditions that contributed to the occurrence. There was no indication that the aircraft had encountered a flight control defect or a structural failure prior to the incident and after the incident. QAR data indicated that external forces applied to aircraft SIA306 disturbed its steady-state flight conditions, and that the upset was not initiated by the aircraft flight control systems.

OTSB concludes that the wake turbulence was likely caused by wing tip vortices, which are a consequence of the differential pressure between the lower and upper wing surfaces subsequently the differential pressure caused the air to move outwards on the lower wing producing counter clockwise cylindrical vortices on the right wing and clockwise rotations on the left wing.

## 2.4 Human Factors

2.4.1 The flight crew of aircraft SIA306 indicated that the reason why they did not respond ATCO`s calls was due to the urgent response to the autopilot trip leading to a momentary deviation of the cleared vertical flight path of the aircraft which was an indication of a sudden and unexpected event which required their full attention in an attempt to regain control of the aircraft hence they did not hear nor respond to the ATCO when they were contacted.

According to the Surveillance Separation Minima, the horizontal separation used over MCT FIR is 5NM. ATC radar screenshot which shows the deviation, there was a potential conflict for aircraft SIA306 to trigger the TCAS alert with the traffic due to the decrease in separation with aircraft AIC946 which was passing from the left to right over WAP SETSI at FL330 and a distance 5.72nm to the right of aircraft SIA306 FL320.

OTSB concludes that the flight crew of aircraft SIA306 had experienced the sudden deflection in the control column and wheel position due to wake turbulence from the reciprocal traffic of aircraft UAE414. This resulted in the tripping of the autopilot and subsequent momentary deviation of the cleared vertical flight path by approximately 500ft. In this occurrence, the flight crew of aircraft SIA306 were assertive because they felt and observed the aircraft altitude change and immediately recovered from the uncommanded roll.

## 2.5 Survivability

2.5.1 Rescue fire service response: There was no services required of Rescue fire, therefore Rescue fire was not a factor to the incident as there was no fire during and after the incident. The cabin service was already completed at the time of the incident and the passengers were asleep during the lull period.

# 3. CONCLUSION

## 3.1. General

From the available evidence, the following findings, causes and contributing factors were made with respect to this incident. These shall not be read as apportioning blame or liability to any organization or individual.

To serve the objective of this investigation, the following sections are included in the conclusion heading:

- **Findings —** are statements of all significant conditions, events, or circumstances in this incident. The findings are significant steps in this incident sequence, but they are not always causal or indicate deficiencies.

## 3.2. Findings

3.2.1 The aircraft SIA306 took off from WSSS with a permissible maximum take-off weight.

3.2.2 The flight plan of aircraft SIA306 was to depart from WSSS, then to fly airways over Indonesia, India and then to enter Oman`s airspace through Way Point (WPT) PARAR and to maintain airway (AWY) P307 to point VAXIM and then to follow AWY L430. After that to enter IRAN airspace through WPT MESPO, and then to continue its flight to EGLL.

3.2.3 The Aircraft was certified, equipped, and maintained in accordance with the existing requirements of the Civil Aviation Authority of Singapore (CAAS).

3.2.4 There was no indication that the aircraft had encountered a flight control defect or a structural failure prior to the incident and there was no reported or recorded defects prior to the flight.

3.2.5 The flight crew members were licensed and qualified for the flight in accordance with the existing requirements of the CAAS.

3.2.6 There was no evidence that incapacitation or physiological factors affected the flight crew performance.

3.2.7 The Crew's actions and statements indicated that their knowledge and understanding of the aircraft systems was adequate.

3.2.8 The flight crew members were well-rested prior to the flight and the Commander was the pilot in command of the Aircraft.

3.2.9 The ATCO held the required licence and medical which was valid at the time of the incident which was issued by Oman CAA.

3.2.10 Environmental conditions indicated predominantly westerly wind conditions at a constant magnitude of 60kts.

3.2.11 The outside air temperature indicated continuous fluctuations with a predominant drop of about -36°C to -39°C as the aircraft flight path approached land mass.

3.2.12 Actual flight conditions experienced by the crew was smooth at FL 320 prior to the event. AWY P307 is a bidirectional airway with ICAO RVSM Standard FLs.

3.2.13 Data from Quick Access Recorder (QAR) confirm the actual flight conditions experienced by crew as indicated by minimal fluctuations in the aircraft Vertical G prior to the event.

3.2.14 According to international standards, collision avoidance during IFR flights is the responsibility of the commander as per the flight plan.

3.2.15 Data from ATC RDR playback and Flight Radar24 showed a reciprocal traffic, Emirates A380 (UAE414) at FL330 on AWY P307 heading east bound.

3.2.16 The time of the reciprocal traffic UAE414 A380 crossed overhead aircraft SIA306 corresponds with the onset of sudden turbulence experienced by the crew.

3.2.17 Although the aircraft were separated by the minimum radar separation standard, while aircraft SIA306 was maintaining FL320, the wake vortices from the opposite direction aircraft UAE414 A380 maintaining FL330 had not dissipated and affected aircraft SIA306.

3.2.18 ATC radar screenshot shows a potential conflicting traffic aircraft AIC946 on an opposite direction on AWY N881 that had crossed WPT SETSI at FL330 and 5.72nm left to the right of aircraft SIA306.

3.2.19 At approximately 2320 UTC, there was a sudden change to the aircraft SIA306 pitch and roll. The Autopilot disconnected 1 second later and the Autopilot Disconnect Warning Aural Alert sounded. The Autopilot disconnect warning is silenced by the PF 1 second later.

3.2.20 The sudden deflection of aircraft SIA306 in the control column and trim wheel position was due to wake turbulence from the reciprocal traffic aircraft UAE414 A380 is the probable cause of the altitude deviation and the tripping of the autopilot.

3.2.21 The wingtip vortices of the heavier aircraft UAE414 A380 contained sufficient energy to significantly destabilize aircraft SIA306 in pitch and roll, which contributed to Autopilot disengagement and roll to the right and left. The cabin service was already completed at the time of the incident and most of the passengers were asleep during the lull period.

3.2.22 According to the reviewed records from ANSIC, SLOP was implemented (ENR 1.10-2 item 5 of the AIP) and a suspension of the SLOP was issued through NOTAM A0365/23 on 07/10/2023 and the suspension of the NOTAM expired on 01/01/2024. Another suspension of SLOP was reissued on 17/01/2024 by NOTAM number A0026/24 which was valid till 08/04/2024 and the suspension of the SLOP was again extended till 02/07/2024 by NOTAM number A0179/24.

3.2.23 The aircraft SIA306 was fitted with both CVR and FDR. However, the recordings were overwritten by the time the OTSB requested the information as the incident was reported 2 days after it had happened.

3.2.24 Control column input applied by the PF was observed to be mild back pressure for 5 seconds before gradually lowered to forward pressure to achieve a shallow nose down pitch towards 2.5°.

3.2.25 The Autopilot was re-engaged at 23:20:50Z, 19 seconds after it disconnected. The total duration the altitude excursion occurred was 28 seconds. The highest altitude reached while in manual flight was 32500ft.

3.2.26 Wake turbulence separation standards do not guarantee avoidance of encounters, they only attempt to minimize the risk.

3.2.27 The OTSB established that the wake turbulence experienced during the cruise flight from SIN to LHR was sudden, the seat belt sign was switched on as required and most of the passengers were reported to be sleeping at the time of the incident.

3.2.28 According to the horizontal separation used within Muscat TMA/CTR is 5NM. ATC radar screenshot which showed the deviation that was a potential conflict for aircraft SIA306 to trigger the TCAS alert with the traffic due to the decrease in separation with aircraft AIC946 which was passing from the left over WAP SETSI at FL330 and a distance 5.72nm to the right of aircraft SIA306 FL320.

## 3.3. **Cause/s**

3.3.1 The OTSB determines that the Incident was due to the tripping of the autopilot and subsequent momentary deviation of the cleared vertical flight path by approximately 500ft caused by an encountered wake vortex generated by aircraft UAE414 (Airbus 380) which was overflying over aircraft SIA306 in the opposite direction on the same airway and at a vertical separation of 1000 ft.

## 3.4. **Contributing Factor/s**

The directed headwind to the aircraft SIA306 caused the wake turbulence to affect aircraft SIA306 as it didn’t drift sideways from its flight path.

## 4. SAFETY RECOMMENDATIONS

### 4.1. General

The safety recommendations listed in this report are proposed according to paragraph 6.8 of Annex 13 to the Convention on International Civil Aviation and are based on the conclusions listed in heading 3 of this report. The OTSB expects that all safety issues identified by the investigation are addressed to the receiving States and organizations/entities.

### 4.2. Safety Recommendation/s

4.2.1 **Safety Actions:** Following the incident the Operator Implemented the Following Preventative Measures:

4.2.1.1 The flight crew of aircraft SIA306 were debriefed on the threats of wake turbulence on bidirectional airways and the use of available mitigation strategies such as Strategic Lateral Offset Procedures (SLOP) was emphasized.

4.1.1.2 The incident was also shared internally through various flight crew platforms for awareness of all pilots.

**4.2.2 Safety Actions:** Following the incident Sultanate of Oman CAA has Implemented the following preventative measures:

4.2.2.1 DGAN is in the process of reviewing and implementing the permanent solution on the SLOP.

5. **APPENDICES**

5.1. Transcript (Appendix A)

23:12:52 SIA306: MCT control hallo SIA306 position PARAR FL320
23:13:00 ALPHA: SIA306 squawk 3526
23:13:02 SIA396: Standby squawking 3526 SIA306
23:13:53 ALPHA: SIA306 identified clear FPL route
23:13:57 SIA306: FPL route SIA306
23:21:08 ALPHA: SIA306 MCT
23:21:21 ALPHA: SIA306 MCT
23:21:27 ALPHA: SIA306 MCT
23:21:36 ALPHA: SIA306 MCT
23:21:46 ALPHA: SIA306 MCT
23:21:55 ALPHA: DLH779 radio check
23:21:57 DLH779: DLH779 go ahead
23:22:01 ALPHA: Radio check
23:22:03 DLH779: DLH779 read you eh… 3 to 4
23:22:07 ALPHA: Roger thank you
23:22:09 ALPHA: SIA306 MCT
23:22:18 ALPHA: SIA306 MCT
23:22:33 ALPHA: SIA306 MCT on guard
23:23:07 AIC946: SIA306 this is AIC946 on guard
23:23:19 AIC946: SIA306 this is AIC946 on guard
23:23:28 AIC946: Calling SIA306 on guard
23:23:42 ALPHA: SIA306 MCT
23:23:44 SIA306: Go ahead SIA306
23:23:46 ALPHA: Confirm you are monitoring your frequency
23:23:52 SIA306: SIA306 say again
23:23:54 ALPHA: Confirm you monitor this frequency
23:23:57 SIA306: We are on this frequency 135.6
23:24:00 ALPHA: Roger I tried to call you before 3 minutes now
23:24:05 SIA306: Ah ok SIA306 on 135.6 level 320
23:24:11 ALPHA: Roger before range 15 miles confirm you climbing eh FL325 and descend again FL320
23:24:22 SIA306: Yes, we faced a turbulence and then eh… aircraft went into eh climb momentarily and we returned back to 320
23:24:33 ALPHA: Roger because you have crossing traffic at SETSI from left to right separation under radar was 3 eh… 5 miles
23:24:41 SIA306: Yes, I think we faced someone's eh…wake turbulence and momentary the aircraft eh autopilot
23:24:48 ALPHA: Roger copied, because I tried to call you no answer
23:24:52 SIA306: Roger I was trying to recover the aircraft
23:24:55 ALPHA: Roger copied

**This report is issued by:**
Air Accident Investigation Section
Oman Transport Safety Bureau (OTSB)
Sultanate of Oman