Taiwan Transportation Safety Board

Major Transportation Occurrence Final Report

June 14, 2020

China Airlines Flight CI202

Airbus A330-302

Registration Number B-18302

The aircraft experienced multiple system failures during landing at Songshan Airport

Report Number: TTSB-AOR-21-09-001

Report Date: September, 2021

According to the Transportation Occurrence Investigation Act of the Republic of China and the International Civil Aviation Organization (ICAO) Annex 13, this report is only for the improvements of flight safety.

Transportation Occurrence Investigation Act of the Republic of China, Article 5:

The objective of the TTSB's investigation of major transportation occurrence is to prevent the recurrence of similar occurrences. It is not the purpose of such investigation to apportion blame or liability.

ICAO Annex 13, Chapter 3, Section 3.1:

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.

Note: The language used in occurrence investigation Final Report is in Chinese. To provide general understanding of this investigation for non-Chinese reader, the Final Report was translated into English. Although efforts are made to translate it as accurate as possible, discrepancies may occur. In this case the Chinese version will be the official version.

Executive Summary

On June 14, 2020, China Airlines scheduled passenger flight CI202, an Airbus A330-302 aircraft, registration B-18302, took off from Shanghai Pudong International Airport for Taipei Songshan Airport with 2 flight crew members, 9 cabin crew members, and 87 passengers, for a total 98 persons onboard. The aircraft landed on runway 10 of Songshan Airport at 1746 Taipei local time. At touchdown, the aircraft experienced the quasi-simultaneous failure of the 3 flight control primary computers (FCPC or PRIM), thus ground spoilers, thrust reversers, and autobrake were lost. The flight crew was aware of the autobrake and reversers failure to activate, and applied full manual brake rapidly to safely stop the aircraft about 30 feet before the end of runway 10 without any damage to the aircraft nor injuries to the passengers onboard.

The relevant document including dispatch sheet, weather information, technical logbook, and deferred defects logbook were checked by the flight crew before their departure from Pudong Airport. There was no anomaly.

The aircraft took off at 1625 with the captain as the pilot flying (PF) and the co-pilot as the pilot monitoring (PM). During descent, the flight crew received the information L from automatic terminal information system (ATIS), and was instructed to use the instrument landing system (ILS) of runway 10. After calculating the landing performance, the Electronic Flight Bag (EFB) showed that there would be 362 feet runway distance remaining if autobrake was set at low.

During the descent and approach phases, no abnormalities were found. About six minutes before landing, the PF was alerted about the rain near Songshan Airport, he asked the PM to review the latest weather information, and learned that the tail wind blew from 280 degrees at 6 knots with a light thunder shower rain. Runway 10 was in use.

At 1743:21, during the final approach, the airplane was at the barometric altitude of about 3,008 feet, the flight crew was informed by the tower that the visibility at the airport had dropped to 2,500 meters.

At 1743:51, the airplane was at the barometric altitude of about 2,480 feet, the tower issued a landing permission: "dynasty 202 runway 10 wind 250 degrees 9 knots caution tail winds clear to land." About fifteen seconds later, the PF reminded the PM, "call out when spoilers deploy so I can tell if the main gear has touched down."

At 1744:37, the airplane was at the barometric altitude of about 1,832 feet, the flight crew conducted landing checklist and the PF asked the PM to set the autobrake from low to medium due to the weather change at Songshan Airport.

At 1745:41, the airplane was at the radio altitude of about 996 feet, the tower reminded that wind speed was 10 knots. Six seconds later, the radio altitude was 919 feet, and the PF said "the wipers can be faster, it's okay", the PM answered "it's at the fastest speed already".

At 1745:58, the airplane was at the radio altitude of about 773 feet, the PM reported "approach lights ahead" and the PF then disengaged the autopilot to continue the approach.

At 1746:41, the airplane was at the radio altitude of about 136 feet, the PM reminded the PF "center line" to maintain on track.

Seven seconds after the aircraft passed the radio altitude of 60 feet, at 1746:54, the aircraft touched down at between 1,500 and 2,000 feet from runway 10 threshold with pitch up about 4.2 degrees, roll to the right at about 1.1 degrees, and its magnetic heading at about 94 degrees. The ground speed was 147 knots (indicated airspeed was 135.5 knots) and the maximum vertical acceleration was 1.28g's. The slats/flaps configuration was FULL. Ground spoilers (i.e. spoilers 2 to 6) started to deploy.

One second after the touchdown, the PM immediately called out "spoilers", while the left and right main gear shifted between air mode and ground mode for about 0.75 seconds and 0.5 seconds respectively. Three seconds after the main gear touched down, autobrake system fault was recorded on FDR. One second later, PRIM1/PRIM2/PRIM3 faults were recorded at the same time and the spoilers retracted, as the ground spoiler function was lost. The PM called out "reverse" and the nose gear touched ground at the same time. After that, the nose gear flipped between air mode and ground mode for nearly 7 seconds.

At 1746:59, the PF asked twice if "autobrake is on" (the ground speed was 141 knots). The PM answered, "autobrake is not on". About five seconds later (1747:04), the PF called out "manual brake", and applied full brake pedal. The normal brake hydraulic pressure value was 448 psi and longitudinal acceleration rate value was about -0.1g, indicating a deceleration.

At 1747:07, the PM called out "reverse no green", about one second later, the PF requested to his first officer "quickly help me brake help me brake" (the ground speed was 127 knots at this time), from then on, both pilots applied full pedals on the brakes manually, the normal brake pressure was up to 576 psi and the longitudinal acceleration rate was -0.14 g 's.

Until 1747:36 when the aircraft came to a full stop at 30 ft before the end of the runway, the aircraft brake pressure and longitudinal acceleration rate fluctuated from 128 psi to 2,560 psi and from -0.05g's to -0.47g's respectively during this period.

According to the Transportation Occurrence Investigation Act of the Republic of China (ROC), and the content of Annex 13 to the Convention on International Civil Aviation, the Taiwan Transportation Safety Board (TTSB), an independent transportation occurrence investigation agency, was responsible for conducting the investigation. The investigation team also included members from France Bureau d'Enquêtes et d'Analyses (BEA), Airbus, EASA, China Airlines and Civil Aeronautics Administration (CAA), Taiwan.

The ‘Draft Final Report’ of the occurrence investigation was, by the procedures, reviewed at TTSB’s 25th Board Meeting on May 07, 2021 and then sent to relevant organizations and authorities for comments. After comments were collected and integrated, the Final Report was reviewed and approved by TTSB’s 29th Board Meeting on August 13, 2021.

There are 15 findings from the Final Report as follows.

I. Findings as the result of this investigation

Findings related to probable causes

1. The three flight control primary computers (FCPCs) of the occurrence aircraft became inoperative almost at the same time during touchdown. The root cause was determined to be an undue triggering of the rudder order COM/MON monitoring concomitantly in the 3 FCPC. At the time of the aircraft lateral control flight law switching to lateral ground law at touch down, the combination of a high COM/MON channels asynchronism and the pilot pedal inputs resulted in the rudder order difference between the two channels to exceed the monitoring threshold. The FCPC1 failed first.
2. After the FCPC1 failure, the master control of flight control system was handed over to FCPC2 and FCPC3 in sequence whose asynchronism were also high at that moment; thus eventually all three FCPCs became inoperative. As a consequence of the three FCPCs loss, the thrust reversers, the ground spoilers, and the autobrake system were lost, resulting in an increased landing distance for the aircraft.

Findings related to risk

1. During landing, flight controls reconfigured from normal law to direct law after all three flight control primary computers (FCPCs) became inoperative. While all aircraft primary control surfaces were still controllable, the deceleration devices including ground spoilers, thrust reversers, and autobrake were lost, the deceleration of aircraft was relied on manual brake by the pilots.
2. Given all three flight control primary computers (FCPCs) failed seconds after touchdown, should other factors (long flare, runway state, …) have affected the landing distance, the aircraft could have overrun the runway even if the pilots had immediately applied maximum manual brake after realizing the autobrake had failed.

Other findings

1. The occurrence flight crew were properly certificated and qualified in accordance with the requirements of the Civil Aviation Authority of Taiwan. Records of training and checks have no anomaly related to this occurrence operation. The rest and activities of flight crew 72 hours before the occurrence were normal. No evidence indicated any pre-existing medical conditions or alcohol that might have adversely affected the flight crew's performance during the occurrence flight.
2. During the approach, flare, landing, and roll out until aircraft came to a full stop, the actions performed by the flight crew complied with stable approach and manual landing Standard Operation Procedures (SOP) prescribed in Flight Crew Operating Manual (FCOM).
3. During the landing roll, the crew kept good interaction and high situation awareness based on pilot-flying's response to decelerating the aircraft and pilot-monitor's call out of relevant abnormal system

status.

4. With three FCPCs inoperative, actual remaining runway distance (30 feet margin) of the occurrence flight was shorter than the calculated value (172 feet margin), possibly due to tailwinds, runway conditions, and manual braking as these factors might increase the braking distance.
5. Ground spoiler function requires at least one functional FCPC, arming autobrake requires at least two functional FCPCs, deployment of thrust reversers require unlock signal from either FCPC1 or FCPC3. As a consequence of the three FCPCs loss, the non-release of the independent locking system prevented the reversers' deployment, the ground spoilers were cancelled and autobrake system was lost.
6. Shop finding of FCPC1 indicated that the unit is no fault found (NFF). The built-in test (BITE) shows SAO（Spécification Assistée par Ordinateur）fault at the time of the triple FCPC fault. The SAO fault corresponds to the fault was trigged during COM/MON monitoring rather than the fault of computer hardware.
7. Following the occurrence, Airbus reviewed its in-service experience, and confirmed that no other triple PRIM fault at touchdown event had been reported on A330/A340 aircraft family since entry into service. The A330/A340 fleet fitted with electrical rudder has accumulated 8.7 millions of Flight Cycles and 44.3 millions of Flight Hours (in-service data from April 2020).
8. The runway surface friction, longitudinal slope, transverse slope, and longitudinal slope changes of the Songshan Airport runway 10 complied with relevant standards.
9. The deceleration performance of the occurrence flight between 6,600 feet and 7,300 feet from the threshold of runway 10 deteriorated. It

may be due to paint marking and rubber deposit on the touchdown zone of runway 28.

10. The occurrence flight first touchdown and second touchdown were about 1,500 feet and 1,800 feet respectively with respect to the runway threshold. The touchdown points were both located at runway touchdown zone.
11. After the flight crew applied manual braking, the overall deceleration performance was between “medium” and “good” level consistent with the reported wet condition of the runway, which should be able to rule out the effect of hydroplaning.

II. Safety Actions

During the investigation, TTSB maintained close communication with all relevant organizations. The aircraft manufacturer, Airbus, provided its proactive safety actions to address the lack of robustness discovered during this investigation with regards to the FCPC COM/MON rudder order monitoring. The Taiwan CAA also released an Aviation Safety Bulletin related to this occurrence on July 13, 2020. The China Airlines released a Flight Operation Information, FOI 2020-034, to his flight crew on July 3, 2020 and updated version (FOI 2021-007) on February 22, 2021. Following are summary of these proactive safety actions.

Safety Actions taken by Airbus

1. Short term actions – Communications to Operators

The objective of these short-term actions was to remind all affected Operators of the importance of the Landing SOP, in particular during the rollout phase, to minimize the consequences of the triple PRIM failure on the aircraft landing distance.

Operators Information Transmission (OIT)

The 28th of July 2020, Airbus issued an Operators Information Transmission (OIT) ATA 27 – A330 Primary Flight Control failures at touchdown (reference 999.0054/20 Rev 00) towards all A330/A340 Operators to inform them of the incident.

The OIT is provided in the Annex 4.

AirbusWIN video

The 28th of December 2020, Airbus published a video on its Worldwide Instructor News website

(AirbusWIN, https://www.airbus-win.com*), which detailed:*

- The deceleration means at landing and the logic behind them

- The standard callouts during landing in normal operations

- The callouts during landing in the event of abnormal operations

The video can be downloaded under the following link: https://www.airbus-win.com/wp-content/uploads/2020/12/what-about-deceleration-means-at-landing-en.mp4

2. *FCPC software enhancement addressing the root cause*

A software enhancement will be implemented in the next FCPC standards on the A330 family, to address the root cause of the B-18302 event:

- P19 for the A330-200 (Ceo) and A330-800 (Neo), targeted for Q3-2022

- M28ceo for the A330-300 (Ceo), targeted for Q3-2023

- M3x for the A330-900 (Neo), targeted for mid 2024

The modification will consist of several system improvements:

- Decrease of the COM/MON asynchronism level for the flight/ground information treatment

- Improvement of the COM/MON rudder order monitoring robustness in case of ground to flight and flight to ground transitions

- *Higher unitary monitoring robustness during such transitions*
- *Avoid cascading/"domino's" effect that leads to several PRIM fault*

3. ***FCPC specification robustness review***

Following the event, Airbus has launched a detailed review of the FCPC software specification, focusing on the COM/MON monitorings during the flight/ground transition. The objective was to detect potential robustness issues, going beyond the scenario of the B-18302 event. At the time of writing of this report, this review is still on-going.

At this stage, Airbus has not identified another type of COM/MON monitoring robustness issue that could result in an undue monitoring triggering with subsequent repercussions having similar level of severity than the B-18302 event.

<u>Safety Actions taken by CAA, Taiwan</u>

Civil Aeronautics Administration released ASB No：109-060/O R1 on July 13, 2020.

Subject:

An ROC-registered A330 encountered a loss of all three primary flight computers (P1/P2/P3), the thrust reverser system and its automatic braking system upon landing on a wet runway. The root cause is still under investigation. All A330 operators shall set countermeasures for the abovementioned condition to ensure flight safety.

Description:

Upon landing on a wet runway with the thrust reverser system activated, the flight crew on an A330 aircraft noticed the loss of all three primary flight computers (P1/P2/P3), the thrust reverser, spoilers and automatic braking systems, thus affecting aircraft deceleration. Maximum manual braking was applied, and the aircraft was stopped right before the end of the runway safely. For safety concerns, the flight crew requested aircraft-towing.

Recommendations:

1. *Before any A330 flight dispatch, consider possible deceleration deficiency with the conditions mentioned above if the runway condition is reported "wet" at the destination airport.*
2. *Corresponding landing distance required on a wet runway shall be predetermined. If the landing distance available is a concern, consider diverting to an alternate airport.*
3. *Operators shall enhance crew's awareness of wet runway operations for proper aircraft deceleration. If automatic braking is out of function, promptly apply manual braking.*
4. *ROC-registered Airbus aircraft operators with similar flight control computers and braking systems should refer to this bulletin to ensure flight safety.*

Safety Actions taken by China Airlines

1. China Airlines released a Flight Operation Information, FOI 2020-034, to her flight crew on July 3, 2020 and updated version (FOI 2021-007) on February 22, 2021.

SUBJECT: *CONSIDERATION FOR LANDING ON SHORT RUNWAY UNDER WET OR SLIPPERY CONDITION*

MESSAGE :

Recently there was a case regarding A330 landed on TSA airport under heavy rain with deceleration devices malfunction.

Before landing on wet or slippery runways, crew should apply FlySmart to calculate 2 landing distances during approach preparation:

1. Normal landing distance,
2. Given condition;
  a. RW condition: Good or reported RWY condition / braking action, whichever is worse
  b. BRK mode: Manual
  c. REV: NO
  d. ECAM: F/CTL SPLRS FAULT (ALL SPLRS)

If the calculated factored landing distance (F-L/D DIST) from condition 2 is marginal, PIC should carefully consider select longer runways, using maximum manual brake, reducing weight or diversion.

Pay extra attention on short runways (such as TSA, KHH, NRT 16L/34R, HND 22, SYD 07/25…etc.). For flare and landing operation, flight crewmember shall be vigilant and close monitor the aircraft system operation such as autobrake and reversers, and take proper actions immediately when necessary such as application of manual brake.

2. *For disseminating potential hazards of the long landing if encountering situation similar to this incident with the condition of short runway, tail wind, and wet runway surface, China Airlines has made the flight safety poster about this case in Q2 2021 and has made it as a lesson learnt in the 1st half EBT briefing to the flight crew to be aware of the long landing risk.*
3. *For disseminating potential hazards of the long landing if encountering situation similar to this incident with the condition of short runway, tail*

wind, and wet runway surface, China Airlines has made the flight safety poster about this case in Q2 2021 and has made it as a lesson learnt in the 1st half EBT briefing to the flight crew to be aware of the long landing risk.

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Abbreviation

ALAR	Approach and Landing Accident Reduction
AOA	Angle of Attack
ATC	Air Traffic Control
ATIS	Automatic Terminal Information System
ATPL	Airline Transport Pilot License
AWOS	Automated Weather Observation System
BITE	Built in Test Equipment
CFIT	Controlled Flight Into or toward Terrain
CMC	Central Maintenance Computer
COM	Command Channel
CVR	Cockpit Voice Recorder
DD	Deferred Defect
EBT	Evidence-Based Training
EFB	Electronic Flight Bag
ECAM	Electronic Centralized Aircraft Monitor
EFCS	Electrical Flight Control System
FCOM	Flight Crew Operating Manual
FCPC	Flight Control Primary Computer
FCSC	Flight Control Secondary Computer
FDR	Flight Data Recorder
FL	Flight Level
FO	First Officer
ICAO	International Civil Aviation Organization
ILS	Instrument Landing System
LLWAS	Low Level Wind Shear Alert System
MAC	Mean Aerodynamic Chord
MON	Monitor Channel
NFF	No Fault Found
NOTAM	Notice To Airmen

NVM	Non-Volatile Memory
PF	Pilot Flying
PFD	Primary Flight Display
PFR	Post Flight Report
PIC	Pilot-in-Command
PM	Pilot Monitoring
PRIM	Flight Control Primary Computer
PSI	Pound per Square Inch
RA	Radio Altimeter
SAO	Spécification Assistée par Ordinateur (computer assisted specification)
SEC	Flight Control Secondary Computer
TLB	Technical Log Book
TLU	Travel Limit Unit
TSD	Trouble Shooting Data
UTC	Coordinated Universal Time

Chapter 1

1.1 History of flight

On June 14, 2020, China Airlines scheduled passenger flight CI202, an Airbus A330-302 aircraft, registration B-18302, took off from Shanghai Pudong International Airport for Taipei Songshan Airport with 2 flight crew members, 9 cabin crew members, and 87 passengers, for a total 98 persons onboard. The aircraft landed on runway 10 of Songshan Airport at 1746[1] Taipei local time. At touchdown, the aircraft experienced the quasi-simultaneous failure of the 3 flight control primary computers (FCPC or PRIM), thus ground spoilers, thrust reversers, and autobrake were lost. The flight crew was aware of the autobrake and reversers failure to activate, and applied full manual brake rapidly to safely stop the aircraft about 30 feet before the end of runway 10 without any damage to the aircraft nor injuries to the passengers onboard.

The relevant document including dispatch sheet, weather information, technical logbook, and deferred defects logbook were checked by the flight crew before their departure from Pudong Airport. There was no anomaly.

The aircraft took off at 1625 with the captain as the pilot flying (PF) and the co-pilot as the pilot monitoring (PM). During descent, the flight crew received the information L from automatic terminal information system (ATIS), and was instructed to use the instrument landing system (ILS) of runway 10. After calculating the landing performance, the Electronic Flight Bag (EFB) showed that there would be 362 feet runway distance remaining if autobrake was set at low.

[1] Unless otherwise noted, the 24-hour clock is used in this report to describe the local time of day. Taipei local time is Universal Coordinated Time (UTC) +8 hours.

During the descent and approach phases, no abnormalities were found. About six minutes before landing, the PF was alerted about the rain near Songshan Airport, he asked the PM to review the latest weather information, and learned that the tail wind blew from 280 degrees at 6 knots with a light thunder shower rain. Runway 10 was in use.

At 1743:21, during the final approach, the airplane was at the barometric altitude of about 3,008 feet, the flight crew was informed by the tower that the visibility at the airport had dropped to 2,500 meters.

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One second after the touchdown, the PM immediately called out “spoilers”, while the left and right main gear shifted between air mode and ground mode for about 0.75 seconds and 0.5 seconds respectively. Three seconds after the main gear touched down, autobrake system fault was recorded on FDR. One second later, PRIM1/PRIM2/PRIM3 faults were recorded at the same time and the spoilers retracted, as the ground spoiler function was lost. The PM called out “reverse” and the nose gear touched ground at the same time. After that, the nose gear flipped between air mode and ground mode for nearly 7 seconds.

At 1746:59, the PF asked twice if “autobrake is on” (the ground speed was 141 knots). The PM answered, “autobrake is not on”. About five seconds later (1747:04), the PF called out “manual brake”, and applied full brake pedal. The normal brake hydraulic pressure value was 448 psi and longitudinal acceleration rate value was about -0.1g, indicating a deceleration.

At 1747:07, the PM called out "reverse no green", about one second later, the PF requested to his first officer “quickly help me brake help me brake” (the ground speed was 127 knots at this time), from then on, both pilots applied full pedals on the brakes manually, the normal brake pressure was up to 576 psi and the longitudinal acceleration rate was -0.14g’s.

Until 1747:36 when the aircraft came to a full stop at 30 ft before the end of the runway, the aircraft brake pressure and longitudinal acceleration rate fluctuated from 128 psi to 2,560 psi and from -0.05g's to -0.47g's respectively during this period.

Figure 1.1-1 The aircraft stopped at the end of runway 10

1.2 Injuries to Persons

None

1.3 Damage to Aircraft

N/A

1.4 Other Damage

N/A

1.5 Personnel Information

1.5.1 Flight Crew Background and Experience

Basic information of the occurrence flight crew is shown in Table 1.5-1

Table 1.5-1 Flight crew basic information

Item	Captain	First officer
Gender	Male	Male
Age as of the Occurrence	55	42
Commenced Employment with CAL	1994/06/24	2016/10/21
License issued	ATPL	CPL
Aircraft Type Rating	A330-300	A330-300 FO
Date of issue	2015/11/17	2017/10/16
Date of expiry	2020/11/16	2022/10/15
Medical certificate issued **Date of expiry**	First class 2020/10/31	First class 2020/10/31
Total flight time [2]	16,168hr. and 32min.	3,791hr. and14min.
Total flight time on A330	8,788hr. and 00 min.	1,711hr. and 24 min.
Total flight time last 12 months	508hr. and 07 min.	642hr. and 22 min.
Total flight time last 90 days	76hr. and 36 min.	111hr. and 39 min.
Total flight time last 30 days	31hr. and 39 min.	48hr. and 16 min.
Total flight time last 7 days	9hr. and 58 min.	11hr. and 15 min.
Total flight time last 24 hours	3hr.and 56 min.	3hr. and 56 min.
Available rest period before occurrence	115hr. and 19 min.	37hr. and 00 min.

[2]The flight time listed in this table includes the flight time of the occurrence flight and is calculated until the time of the occurrence.

1.5.1.1 The Captain

The Captain was a Republic of China citizen. He joined CAL in June 1994 and became a cadet in the seventh class of the China Airlines pilot training course. He went to the University of North Dakota (UND) Flight Training Center for training. After finishing the training, he returned to Taiwan to receive training on Boeing 747-200, and then transferred to Airbus A300-600R, A340, A330. In July 2013, he completed the A330 command upgrade training and passed the line check then served as a captain in A330 fleet. The total personal cumulative flight time is 16,168 hours and 32 minutes, of which the A330-300 aircraft flight time is 8,788 hour

The Captain held an air transport pilot license (ATPL) issued by the Civil Aeronautics Administration(CAA) with multi-engine land, Instrument Rating A-330 A-340, endorsed with privileges for the operation of radiotelephone on board an aircraft with limitation ”A-340 F/O” and English Proficient: ICAO L4 Expiry Date 2022-01-15.

The Captain passed his latest evidence-based training (EBT) with “Satisfactory” on 2019-04-04 and passed the annual line check on 2019-06-23. After reviewing the captain's training and check records of the year, no anomaly finding was noted related to the occurrence flight.

The Captain’s first-class medical check was done at the Aviation Medical Center of the Civil Aviation Administration of the Ministry of Communications (hereinafter referred to as the Aviation Medical Center) on 2020-04-08 and a certificate was issued by the CAA with the limitation that the “Holder shall wear corrective lenses”. The Expiry date of the medical certificate is October 31, 2020.The result of the captain’s alcohol test performed by the RCSS operation officer after the occurrence indicated the alcohol value was zero.

1.5.1.2 The First Officer

The First Officer, a Republic of China citizen, had served in the Air Force as a pilot and joined CAL in October 2016. He was transferred to the A300 fleet in September 2016 and successfully completed A330 first officer training in November 2016 then served as a first officer. He has a total flight time of approximately 3,791 hours and 14 minutes, of which the A330-300 flight time is 1,711 hours and 24 minutes.

The First Officer held a commercial pilot license (CPL) issued by the Civil Aeronautics Administration (CAA) with multi-engine land, Instrument Aeroplane A-330, endorsed with privileges for the operation of radiotelephone on board an aircraft with limitation “A-330 F/O” and English Proficient: ICAO L5 Expiry Date 2023-09-12.

The First Officer passed his latest evidence-based training (EBT) with ”Satisfactory” on 2019-09-09 and passed the annual line check on 2019-12-23. After reviewing the First Officer's training and check records of the year, no anomaly finding was noted related to the occurrence flight.

The First Officer’s first-class medical check was done at the Aviation Medical Center of the Civil Aviation Administration of the Ministry of Communications (hereinafter referred to as the Aviation Medical Center) on 2020-04-01 and certificate was issued by the CAA with the limitation that the “Holder shall wear corrective lenses”. The Expiry date of the medical certificate is October 31, 2020.The result of the First Officer’s alcohol test performed by the RCSS operation officer after the occurrence indicated the alcohol value was zero.

1.5.2 Flight Crew Activities within 72 Hours

The Captain

6/10~6/13 Annual leave

June 11th: Woke up at 0700 Taipei time (good sleep quality). Ate breakfast in Taitung Hotel from 0730~0830. 0900~1700 family activities. Ate dinner in Taitung from 1800~2000. Went to bed at 2300 and fell asleep about ten minutes later.

June 12th: Woke up at 0700 Taipei time (good sleep quality). Had breakfast in Taitung from 0730~0830. 0900~1730 family activities. Had dinner in Hualien from 1730~1930. Went to bed at 2300 and fell asleep about ten minutes later.

June 13th: Woke up at 0700 Taipei time (good sleep quality). Had breakfast in Hualien from 0730~0830. At 0900, on the way to Taipei, and arrived home around 1500. Had dinner at home from 1800 to 1900. Went to bed at 2300 and fell asleep about ten minutes later.

June 14th: Woke up at 0800 Taipei time (good sleep quality). Ate breakfast at home from 0830~0930. Report to China Airlines for flight at 1100 and performed CI-201/CI202 duty.

<u>The First Officer</u>

June 11th: Woke up at 0630 Taipei time (went to bed at 2300 the night before, and fell asleep about 15 minutes later. The quality of sleep was good and no external factors interfered). At 0730 Taipei time, drove child to school and back home at 0745. Went out to buy lunch at 1200 and returned home at 1230. Picked up child from cram school at 1800 and returned home at 1815. Went to bed at 2230 and fell asleep 10-15 minutes later. The quality of sleep was good without external interference factors.

June 12th: Standby mission started at 0400 Taipei time. Woke up at 0620 and sent child to school at 0730. Returned home at 0745. Did some running and gym works in house from 0900-1000. Went out to buy lunch at 1200 and returned home at 1230. Picked up child from school at 1730 and returned home at 1745. Picked up another child from the cram school at 1900 and returned home around 1915. Went to bed at 2300 and fell to asleep about 10-15 minutes later, the quality of sleep was good, no external interference factors.

June 13th: Woke up at 0730 Taipei time. Did some running and gym works in house from 1600-1700. Went out to buy dinner at 1900 and returned home at 1930. Went to bed at 2300 and fell asleep about 10-15 minutes later, the quality of sleep was good.

June 14th: Woke up at 0700 Taipei time (good sleep quality). Ate breakfast at home from 0800~0900. Departed for Company at Taoyuan from home at 0845-0930. Departed for Company at Songshan with crew bus at 1010 to perform CI-201/CI202 duty.

1.6 Aircraft Information

1.6.1 Aircraft and Engine Basic Information

Basic information of the occurrence aircraft is shown in Table 1.6-1.

Table 1.6-1 Aircraft basic information

Aircraft basic information (statistics date: 14 June 2020)	
Nationality	Taiwan, R.O.C.
Aircraft registration number	B-18302
Aircraft Model	A330-302
Manufacture	AIRBUS S.A.S.
Aircraft serial number	0607
Date manufactured	July 8, 2004
Delivery date	July 9, 2004
Owner	Altitude Aircraft CAL I Limited
Operator	China Airlines
Number of certificate of registration	93-938
Certificate of airworthiness No.	109-04-068
Certificate of airworthiness, validity date	April 16, 2020
Certificate of airworthiness, due date	April 15, 2021
Total flight time (hours)	44,909.35
Total flight cycles	20,625
Last Check	C11
Last check date	March 17, 2020
Flight hours elapsed since last check	161.2
Flight cycles elapsed since last check	89
Max. takeoff weight	230,000 kg/ 507,058 lb.
Max. landing weight	185,000 kg/ 407,851 lb.

Basic information for the two General Electric Company, GE CF6-80E1A4 engines is shown in Table 1.6-2.

Table 1.6-2 Engine basic information

Engine basic information (statistics date: 14 June 2020)		
Manufacture	General Electric Company	
Number/position	No. 1 /Left	No. 2 /Right
Model	CF6-80E1A4	CF6-80E1A4
Serial number	811257	811593
Manufacture date	February 25, 2004	November 9, 2011
Times since last shop check	2,698.77	1,012.53
Cycles since last shop check	1,168	447
Times since installation	43,900.6	29,500.27
Cycles since installation	16,168	8,747

1.6.2 Aircraft Maintenance Records

A review of the aircraft's maintenance records before the occurrence flight indicated that there were no defects reported or inoperative items under the minimum equipment list for the occurrence flight when the aircraft was dispatched. A review of the aircraft's Service Bulletins (SBs) or airworthiness directives (ADs). The review also concluded that the aircraft was in compliance with all applicable ADs and SBs. The followings were maintenance actions after the occurrence flight was completed:

- *REPORT: AUTO BRK INOP AFT LDG TOUCH DOWN.*

  ACTION: 1. IAW TSM 32-42-00-810-821-A, R64, AMM 32-46-00, R64, PFM BSCU BITE TEST OK. 2. GND CK NO PFR FAULT.

- *REPORT: THR REV FAULT (INOP) AFT LDG TOUCH DOWN.*

  ACTION: 1. PFR FAULT CODE: 279334. 2. IAW TSM 27-90-00-

810-836A, R64, & AMM 27-93-34, R64, RPLD FCPC1. 3. IAW AMM 27-93-00, R64, FCPC OPS TEST NML & PFM AMM 22-97-00, R64, LAND CAT III CAPABILITY TEST OK.

- *REPORT: F/CTL PRIM 1 FAULT AFT LANDING*

  ACTION: 1. CK PFR FAULT CODE: 279334. 2. IAW TSM 27-90-00-810-836-A, R64, &AMM 27-93-34, R64, RPLD FCPC 1. 3. PER AMM 27-93-00, R64, OPS TEST OF FCPC NML & AMM 22-97-00, R64, PFM LAND CAT III CAPABILITY TEST OK.

- *REPORT: F/CTL PRIM 2 FAULT AFT LANDING*

  ACTION: 1. PFR FAULT CODE: 279334. 2. IAW TSM 27-90-00-810-836-A, R64, &AMM 27-93-34, R64, RPLD FCPC 1. 3. IAW AMM 27-93-00, R64, FCPC OPS TEST NML & PFM AMM 22-97-00, R64, LAND CAT III CAPABILITY TEST OK.

- *REPORT: F/CTL PRIM 3 FAULT AFT LANDING*

  ACTION: 1. PFR FAULT CODE: 279334. 2. IAW TSM 27-90-00-810-836-A, R64, &AMM 27-93-34, R64, RPLD FCPC 1. 3. IAW AMM 27-93-00, R64, FCPC OPS TEST OK & PFM AMM 22-97-00, R64, LAND CAT III CAPABILITY TEST OK.

- *REPORT: F/CTL DIRECT LAW (PROT LOST) AFT L/D.*

  ACTION: 1. PFR FAULT CODE: 279334. 2. IAW TSM 27-90-00-810-836-A, R64, &AMM 27-93-34, R64, RPLD FCPC 1. 3. IAW AMM 27-93-00, R64, FCPC OPS TEST NML & PFM AMM 22-97-00, R64, LAND CAT III CAPABILITY TEST OK.

- *REPORT: GND CK FOUND RH SIDE N.L.G. NOSE TIRE*

WORN OUT.

ACTION: 1. IAW AMM 32-41-12, R64, GND RPLD NLG RH SIDE NOSE TIRE. 2. GND SVC TIRE PRESSURE TO 170 PSI AND NO AIR SEEPING FOUND. IND NML PER AMM 12-14-32, R64, TPIS TEST OK PER AMM 32-49-00, R64.

- *REPORT: NUMBER 3 MAIN WHEEL & TIRE ASSY WORN OUT.*

  ACTION: 1. IAW AMM 32-41-11, REV 64, PFM THE MAIN WHEEL & TIRE ASSY RPLD AND CONDITION CHK NML. 2. IAW AMM 12-14-32, R64, DO THE MAIN WHEEL & TIRE PRESSURE SVC TO 215 PSI AND LEAK TEST NML. 3. IAW AMM 32-49-00, R64, TPIS BITE TEST OK AND BRAKE FAN OPS TEST OK PER AMM 32-48-00, R64.

1.6.3 Aircraft System Records

Post Flight Report

Table 1.6-1 and 1.6-2 shows the PFR (post flight reports) from CFDS (Centralized Fault Display System). The reports are listed in time sequence as follows:

UTC 0946：NOT DISPLAYED

F/CTL PRIM 1 FAULT

UTC 0946：NOT DISPLAYED

F/CTL PRIM 2 FAULT

UTC 0946：NOT DISPLAYED

F/CTL PRIM 3 FAULT

UTC 0947：F/CTL DIRECT LAW

UTC 0947：NOT DISPLAYED

ENG 1 REVERSE FAULT

UTC 0947：FLAG ON CAPT PFD

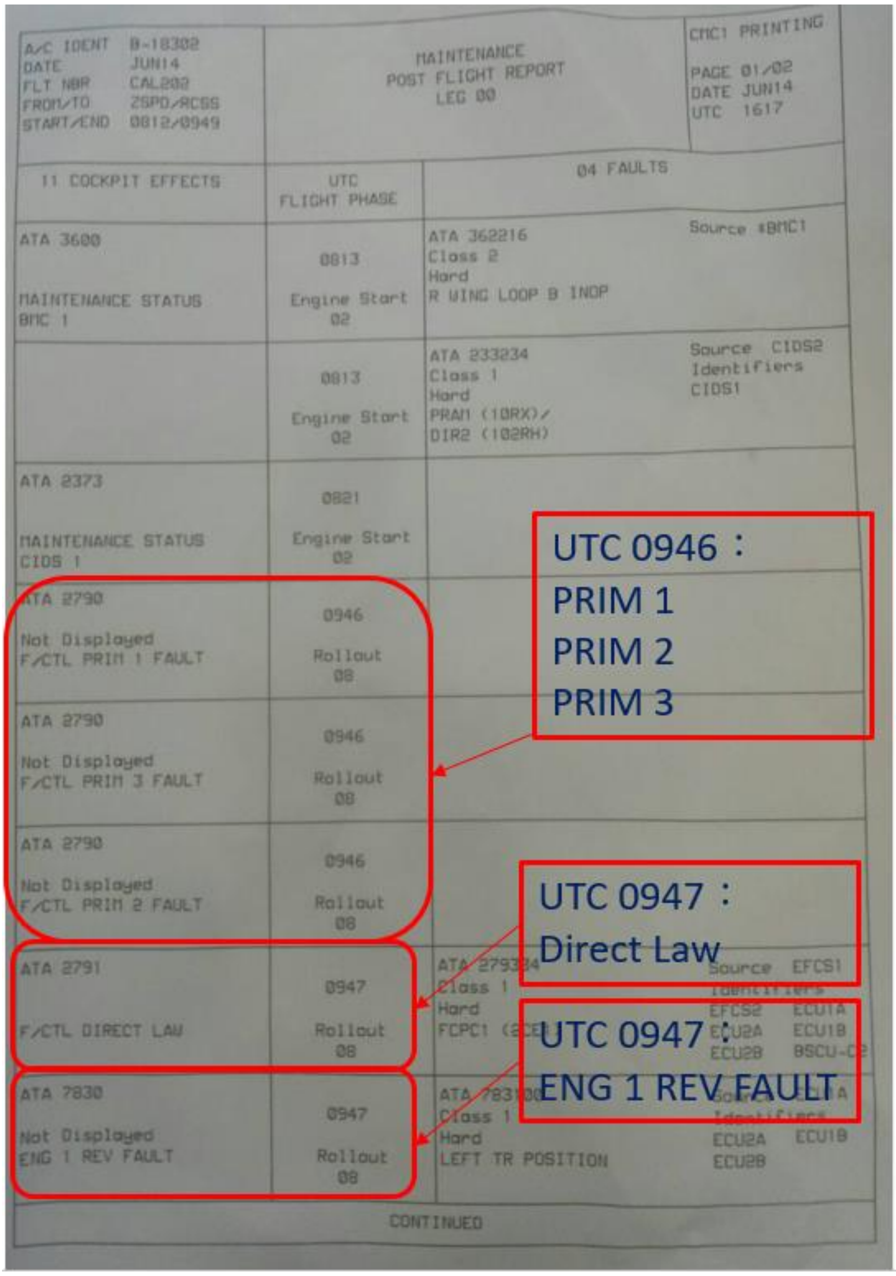
USE MAN PITCH TRIM

UTC 0947：FLAG ON F/O PFD

USE MAN PITCH TRIM

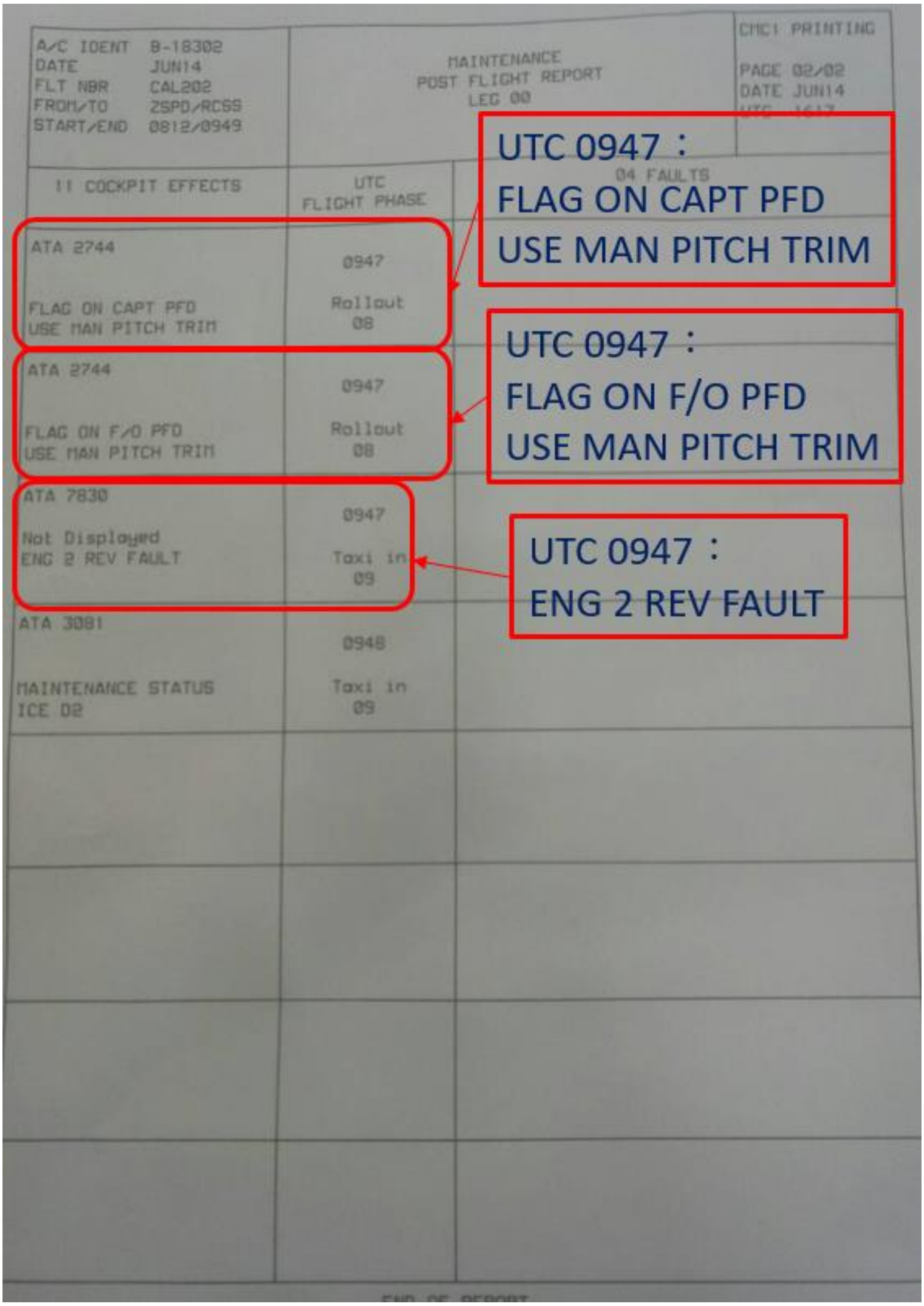
UTC 0947：NOT DISPLAYED

ENG 2 REVERSE FAULT



A/C IDENT B-18302 DATE JUN14 FLT NBR CAL202 FROM/TO ZSPD/RCSS START/END 0812/0949	MAINTENANCE POST FLIGHT REPORT LEG 00		CMC1 PRINTING PAGE 01/02 DATE JUN14 UTC 1617
11 COCKPIT EFFECTS	UTC FLIGHT PHASE	04 FAULTS	
ATA 3600 MAINTENANCE STATUS BMC 1	0813 Engine Start 02	ATA 362216 Class 2 Hard R WING LOOP B INOP	Source #BMC1
	0813 Engine Start 02	ATA 233234 Class 1 Hard PRAM (10RX)/ DIR2 (102RH)	Source CIDS2 Identifiers CIDS1
ATA 2373 MAINTENANCE STATUS CIDS 1	0821 Engine Start 02		
ATA 2790 Not Displayed F/CTL PRIM 1 FAULT	0946 Rollout 08		
ATA 2790 Not Displayed F/CTL PRIM 3 FAULT	0946 Rollout 08		
ATA 2790 Not Displayed F/CTL PRIM 2 FAULT	0946 Rollout 08		
ATA 2791 F/CTL DIRECT LAW	0947 Rollout 08	ATA 2793... Class 1 Hard FCPC1 (...	Source EFCS1 Identifiers EFCS2 ECU1A ECU2A ECU1B ECU2B BSCU-C...
ATA 7830 Not Displayed ENG 1 REV FAULT	0947 Rollout 08	ATA 7831... Class 1 Hard LEFT TR POSITION	Source ... Identifiers ECU2A ECU1B ECU2B
CONTINUED			

Figure 1.6-1 PFR 1/2

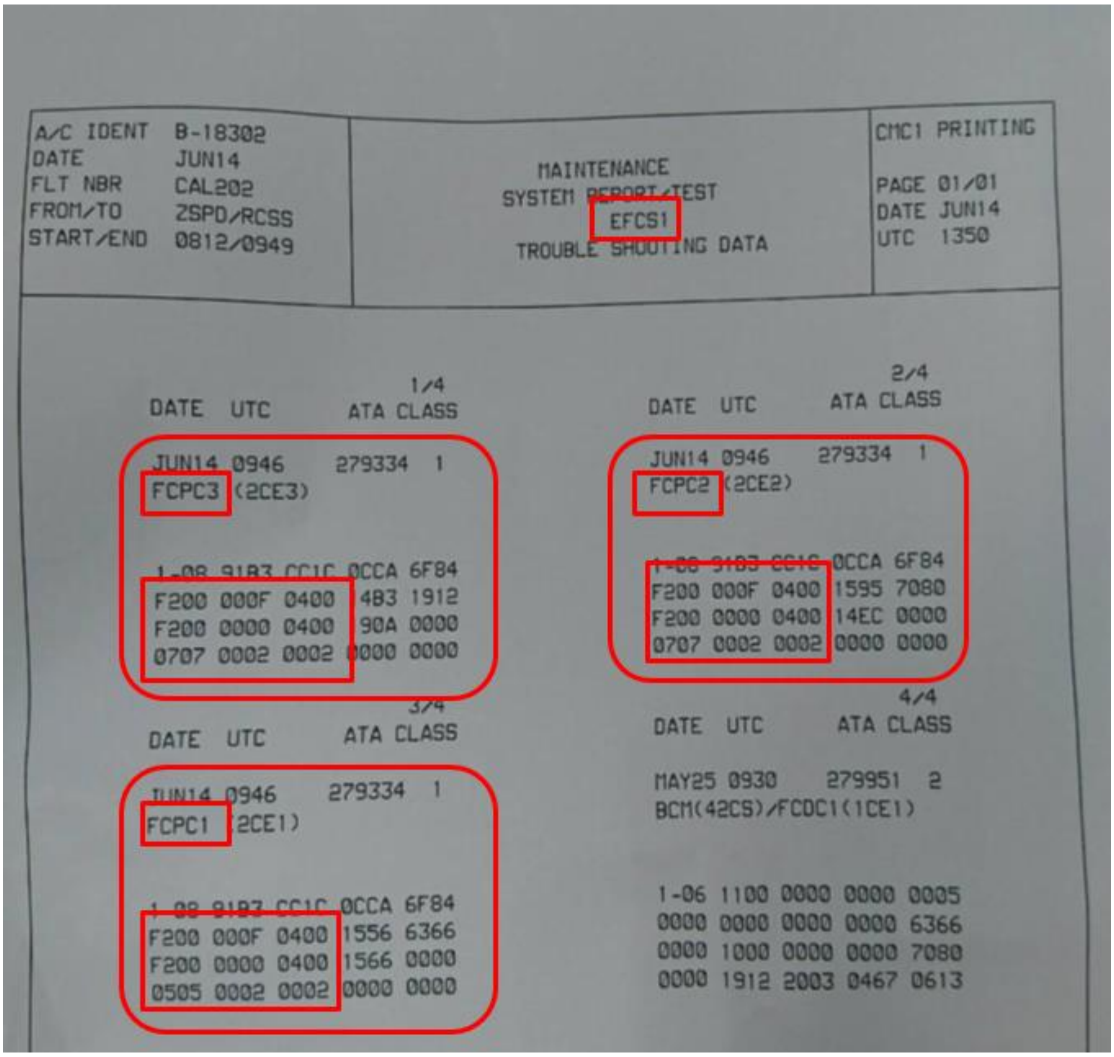


A/C IDENT B-18302 DATE JUN14 FLT NBR CAL202 FROM/TO ZSPD/RCSS START/END 0812/0949	MAINTENANCE POST FLIGHT REPORT LEG 00	CMC1 PRINTING PAGE 02/02 DATE JUN14
11 COCKPIT EFFECTS	UTC FLIGHT PHASE	04 FAULTS
ATA 2744 FLAG ON CAPT PFD USE MAN PITCH TRIM	0947 Rollout 08	
ATA 2744 FLAG ON F/O PFD USE MAN PITCH TRIM	0947 Rollout 08	
ATA 7830 Not Displayed ENG 2 REV FAULT	0947 Taxi in 09	
ATA 3081 MAINTENANCE STATUS ICE D2	0948 Taxi in 09	

Figure 1.6-2 PFR 2/2

EFCS trouble shooting data (TSD)

TSDs were extracted from the aircraft CMC after the event, as shown in Figure 1.6-3 and Figure 1.6-4. Both EFCSs indicate that all 3 FCPCs showed the same fault messages.



A/C IDENT B-18302
DATE JUN14
FLT NBR CAL202
FROM/TO ZSPD/RCSS
START/END 0812/0949

MAINTENANCE
SYSTEM REPORT/TEST
EFCS1
TROUBLE SHOOTING DATA

CMC1 PRINTING

PAGE 01/01
DATE JUN14
UTC 1350

1/4
DATE UTC ATA CLASS

JUN14 0946 279334 1
FCPC3 (2CE3)

1-08 9183 CC1C 0CCA 6F84
F200 000F 0400 483 1912
F200 0000 0400 90A 0000
0707 0002 0002 0000 0000

2/4
DATE UTC ATA CLASS

JUN14 0946 279334 1
FCPC2 (2CE2)

1-08 9183 CC1C 0CCA 6F84
F200 000F 0400 1595 7080
F200 0000 0400 14EC 0000
0707 0002 0002 0000 0000

3/4
DATE UTC ATA CLASS

JUN14 0946 279334 1
FCPC1 (2CE1)

1-08 9183 CC1C 0CCA 6F84
F200 000F 0400 1556 6366
F200 0000 0400 1566 0000
0505 0002 0002 0000 0000

4/4
DATE UTC ATA CLASS

MAY25 0930 279951 2
BCM(42CS)/FCDC1(1CE1)

1-06 1100 0000 0000 0005
0000 0000 0000 0000 6366
0000 1000 0000 0000 7080
0000 1912 2003 0467 0613

Figure 1.6-3 EFCS1 trouble shooting data

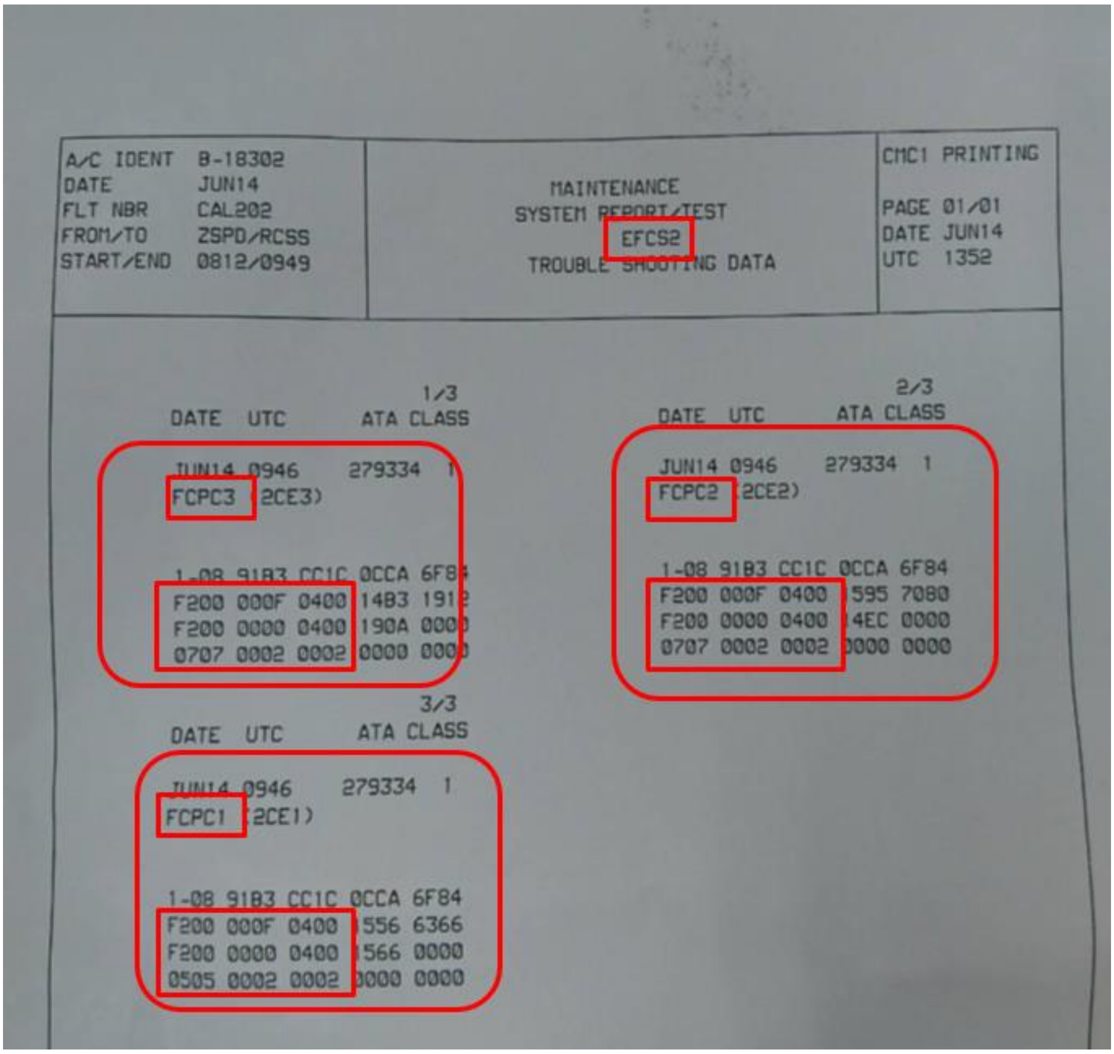


Figure 1.6-4 EFCS2 trouble shooting data

1.6.4 A330 Electrical Flight Control System (EFCS)

1.6.4.1 EFCS introduction

Airbus A330 EFCS is a flight-by-wire system. There is no direct mechanical linkage between sidestick and control surface deflection. The pilot's commands are transmitted to flight control computers and the computers convert electrical signals to hydraulic actuators and use hydraulic power to control the flight control surfaces. The monitor system transmits the response of the surfaces and feedback to flight control computer.

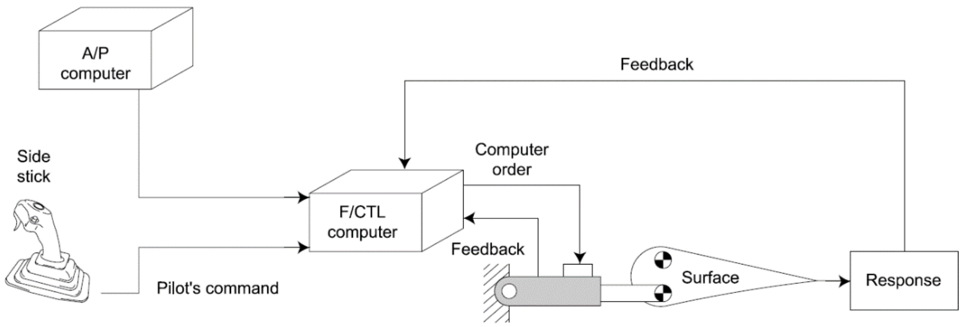


Figure 1.6-5 Electrical Flight Control System

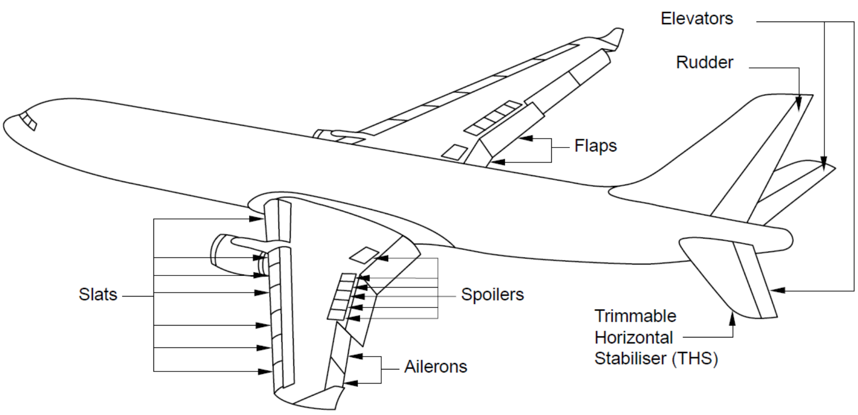


Figure 1.6-6 A330 control surfaces

Five flight control computers including three flight control primary computers (FCPC or PRIM) and two flight control secondary computers (FCSC or SEC) process pilot and autopilot inputs according to normal, alternate or direct flight control laws.

- Three flight control primary computers , each of which is used for :
  - Normal, alternate, and direct control laws.
  - Speedbrake and ground spoiler control.
  - Protection speed computation.
  - Rudder travel limit.
- Two flight control secondary computers for,
  - Direct control laws, including yaw damper function.
  - Rudder trim, and rudder travel limit.

In normal operation, one PRIM computer is declared to be the master (P1). It processes the orders and sends them to the other computers (P1 / P2 / P3 / S1 / S2), which will then execute them on their related servo-control. If one computer is unable to execute the orders sent by the master, another computer executes the task of the affected computer (except for spoiler control). If the master computer (P1) cannot be the master, then P2 (or P3, if P2 is not available) becomes the master. In case all PRIM computers are lost, each SEC is its own master and controls its associated servo loop in direct law. A single SEC can provide complete aircraft control in direct law.

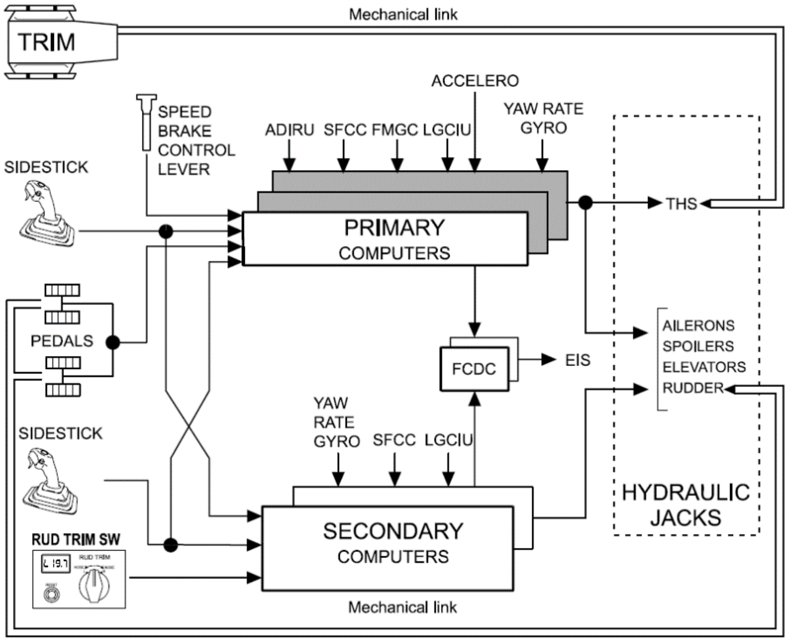


Figure 1.6-7 EFCS system diagram

1.6.4.2 Flight control law and FCPC

Under normal conditions even after single failure of sensors, electrical system, hydraulic system or flight control computer, the flight control system is in Normal Law. Depending on the type of failures affecting the flight control system, or its peripherals, there are 3 possible reconfiguration levels:

- Alternate law (ALT 1 or ALT 2)
- Direct law, or
- Mechanical.

Each control law provides different protections as follows,

Normal Law – protections: The normal law provides complete flight envelope protection as follows:

- Load factor limitation
- Pitch attitude protection
- High angle of attack (AOA) protection

- High speed protection

Alternate Law Protections:
- Pitch attitude: lost
- High speed: replaced by static stability
- High angle of attack: replaced by static stability
- Low energy: lost

Direct Law:
- All protections are lost

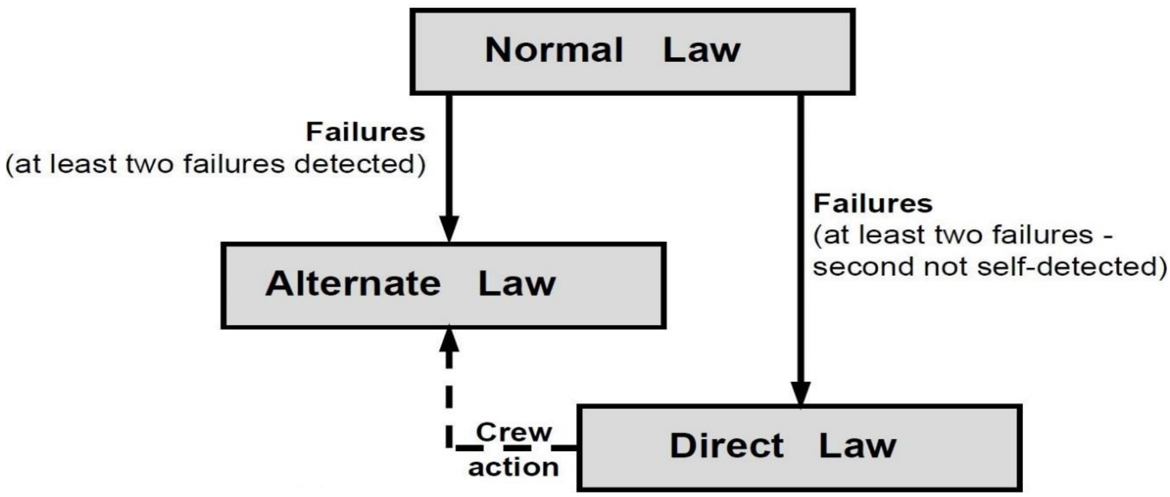


Figure 1.6-8 EFCS Flight Control Law

The three flight control primary computers (FCPC):

Three FCPCs generate the commands necessary to deflect the primary flight control surfaces. To do this, they use the normal flight laws, or the direct and alternate laws. Each FCPC is able to control up to eight servo-loops simultaneously. Each can provide complete aircraft control under normal laws. Each FCPC has two channels: a command channel (COM) and a monitor channel (MON). The two channels are electrically segregated and mechanically separated by two partitions which form a ventilation well. One of the three FCPC is selected to be the master. It processes the orders and outputs them to the other computers (FCPC 1, 2 and 3, FCSC 1 and 2) which will then execute them on their related servo-loop. The master checks orders emitted by one channel by comparing them with orders computed on the other channel. This allows self-monitoring of the master which can detect a malfunction and cascade control to the next computer.

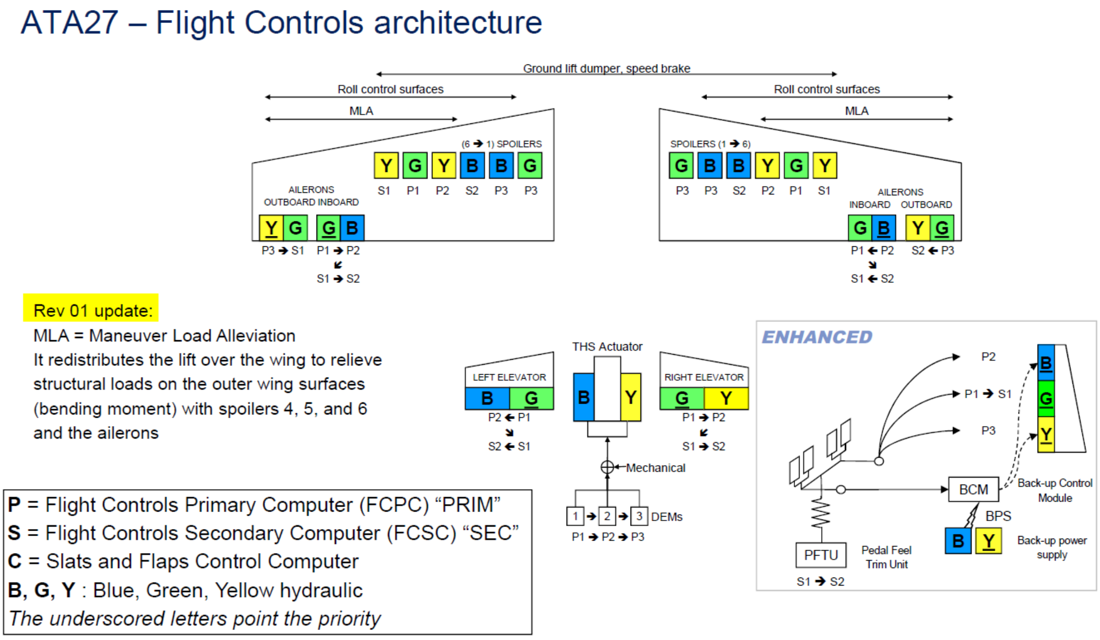


Figure 1.6-9 FCPC and flight control surfaces diagram

As a consequence of the three FCPCs (P1, P2, P3) loss, the master control of the flight control system is changed over to flight control secondary computer FCSC(S1, S2), with the following repercussions,

- flight controls reconfigured from normal law to direct law;
- speed brake and ground spoilers only no.3 and no.6 available for roll operation;
- loss of nose gear steering by rudder pedals; (tiller still available)；
- autobrake loss；
- thrust reverser loss

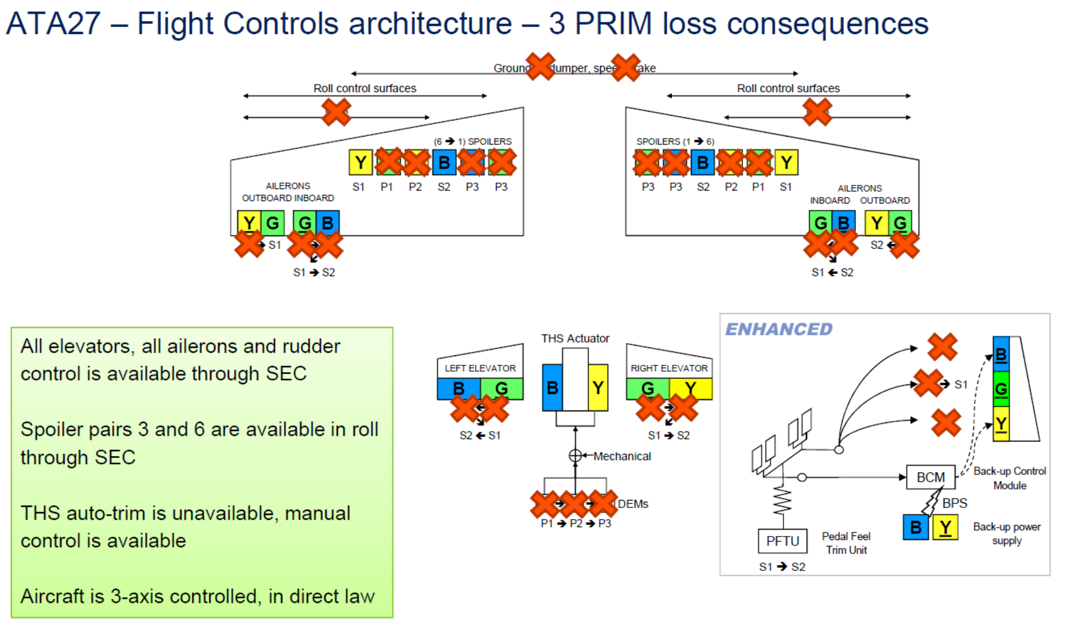
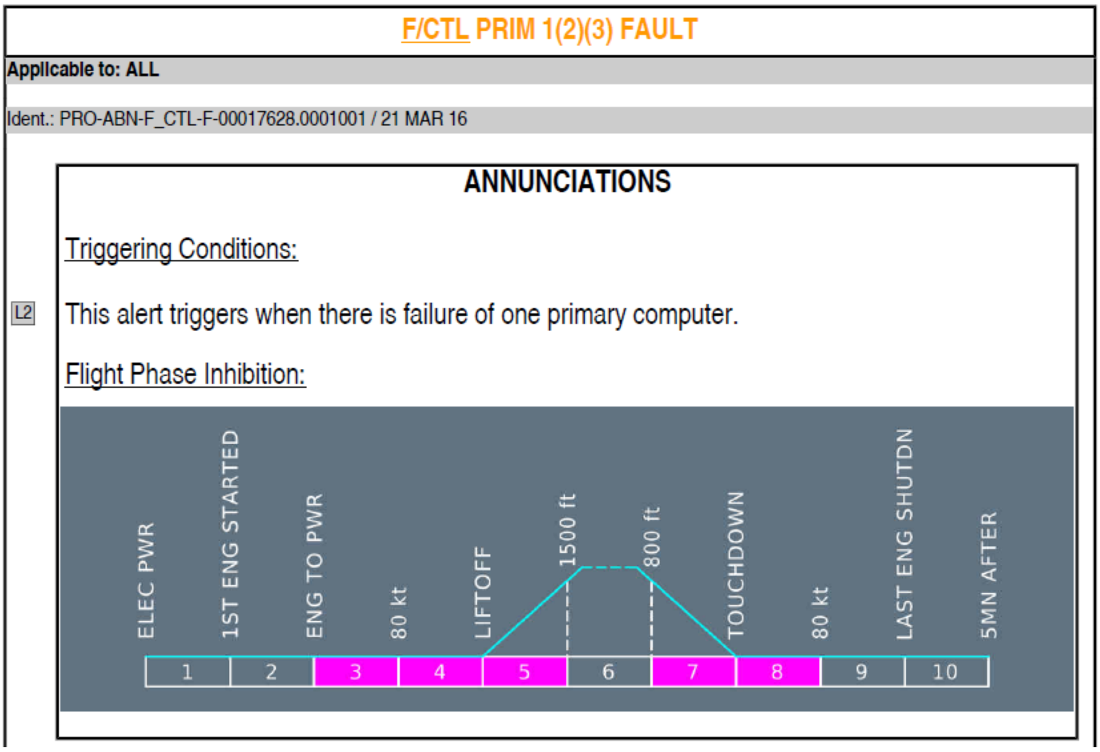


Figure1.6-10 All 3 FCPC loss consequences

1.6.4.3 ECAM message inhibits

In order to reduce work load from pilots, ECAM (electronic centralized aircraft monitor, ECAM) inhibits unnecessary alert/warning/caution messages in some flight phases such as phase 3, 4 and 5 (takeoff) or phase 7 and 8 (landing). In the occurrence flight, the F/CTL PRIM 1, PRIM 2, and PRIM 3 fault messages were inhibited as indicated in Figure 1.6-11.



F/CTL PRIM 1(2)(3) FAULT

Applicable to: ALL

Ident.: PRO-ABN-F_CTL-F-00017628.0001001 / 21 MAR 16

ANNUNCIATIONS

Triggering Conditions:

L2 This alert triggers when there is failure of one primary computer.

Flight Phase Inhibition:

Figure1.6-11 F/CTL PRIM 1(2)(3) FAULT message inhibit.

1.6.5 Weight and Balance Information

According to the occurrence flight's computer load/trim sheet, weight and balance data as detailed in Table 1.6-3. The CG envelope is depicted in Figure 1.6-12. Actual weight and CG were within the certified limits.

Table 1.6-3 Weight and balance data

Max. zero fuel weight	381,396 lbs.
Actual zero fuel weight	326,254 lbs.
Max. takeoff weight	451,942 lbs.
Actual takeoff weight	358,867 lbs.
Take off fuel	32,613 lbs.
Estimated trip fuel	18,693 lbs.
Max. landing weight	407,851 lbs.
Estimated landing weight	343,000 lbs.
Take off Center of Gravity	23.4% MAC
Zero fuel weight Center of Gravity	22.5% MAC
MAC: mean aerodynamic chord. Takeoff and zero fuel weight CG envelope between 20% to 37%	

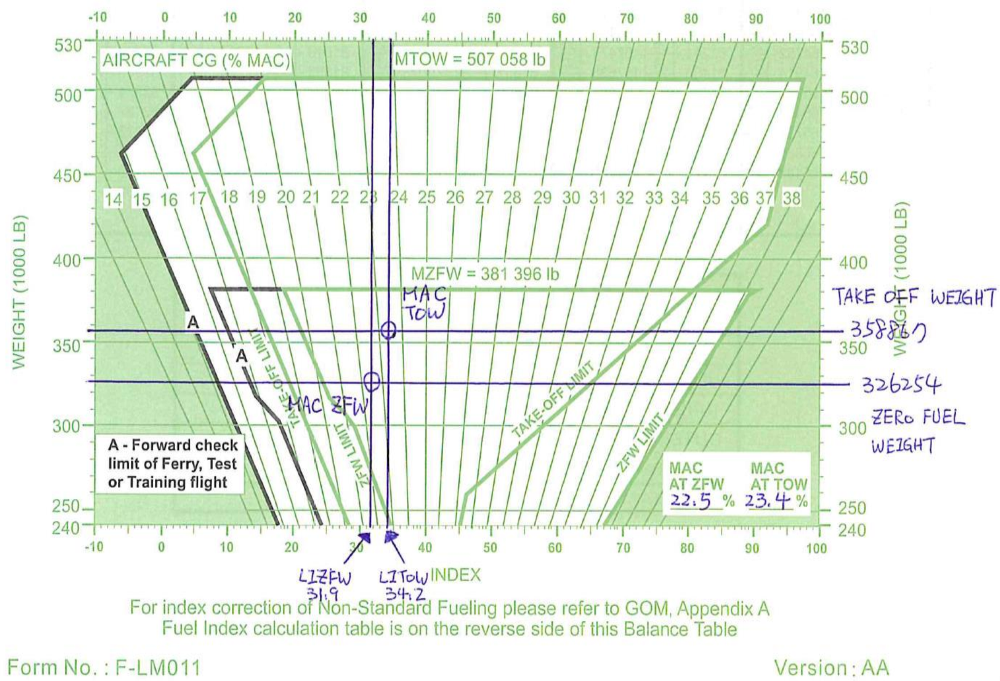


Figure 1.6-12. CG envelope

1.7 Weather Information

1.7.1 Synopsis

The Asian surface analysis chart at 1400 hours on the day of the occurrence showed a low-pressure of 1004 hPa located on the northern Hainan Island and moved west-northwest at a speed of 15 knots. Taiwan was affected by high pressure system, southerly winds and land-sea winds were prevailed, and the northern Taiwan was prone to afternoon thunderstorm. According to the infrared satellite image (figure 1.7-1) and the Doppler weather radar image (figure 1.7-2) at 1750 hours, the convective cloud systems were located in northern and central Taiwan, and the radar echo intensity over Songshan Airport was about 40 to 45 dBZ.

The significant meteorological information (SIGMET) for Taipei FIR that was valid at the time of the occurrence is as follows, Songshan Airport was within the forecast area:

SIGMET 2- valid from 1700 to 2100 hours in Taipei FIR; embedded thunderstorms were forecasted within N2530 E12230, N2530 E12100, N2330 E12000 and N2330 E12130 with cloud top at FL420, moving NE at 5 knots; no changes in intensity were expected.

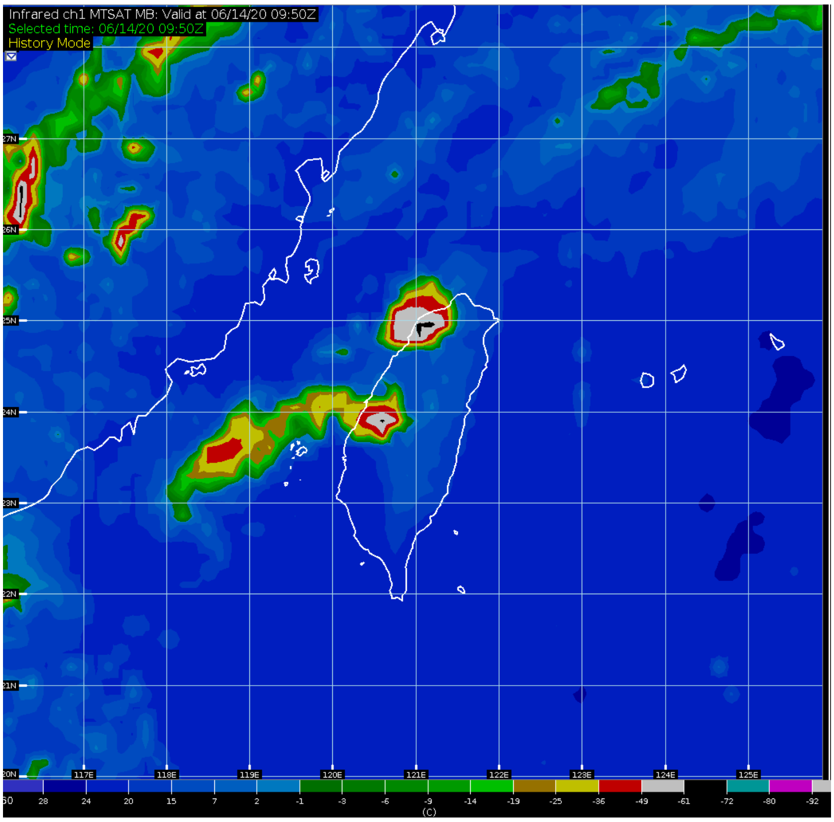


Figure 1.7-1 Infrared satellite image at 1750 hours

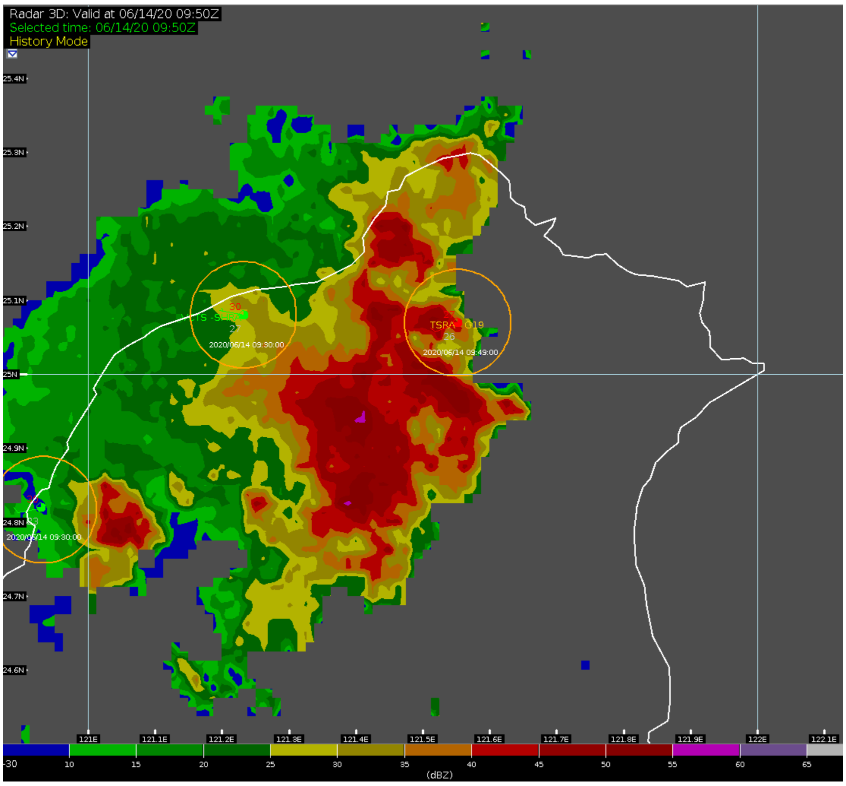


Figure 1.7-2 North Taiwan weather radar image at 1750 hours

1.7.2 Surface Weather Observations

The aerodrome routine meteorological reports (METAR) and aerodrome special meteorological report (SPECI) for Songshan Airport around the time of the occurrence are as follows:

METAR at 1700 hours, wind from 280 degrees at 3 knots, wind direction variations from 260 to 320, visibility 7,000 meters in light thunderstorm rain, few clouds at 1,400 feet, few cumulonimbus at 1,800 feet, broken clouds at 2,500 feet, broken clouds at 6,000 feet, temperature 29°C; dew point temperature 27°C, altimeter setting 1,011 hPa; trend forecast-becoming visibility 3,000 meters in thunderstorm rain; Remarks: thunderstorm in the southwest moving north, altimeter setting 29.87 in-Hg, hourly precipitation 2.2 millimeters. (ATIS L)

SPECI at 1707 hours, wind from 260 degrees at 4 knots, wind direction variations from 230 to 290, visibility 7,000 meters in light thunderstorm rain, few clouds at 1,200 feet, few cumulonimbus at 1,600 feet, broken clouds at 2,500 feet, broken clouds at 4,500 feet, temperature 29°C; dew point temperature 27°C, altimeter setting 1,011 hPa; trend forecast-becoming visibility 3,000 meters in thunderstorm rain; Remarks: thunderstorm overhead, altimeter setting 29.88 in-Hg. (ATIS M)

METAR at 1730 hours, wind from 290 degrees at 5 knots, wind direction variations from 260 to 320, visibility 7,000 meters in light thunderstorm rain, few clouds at 800 feet, few cumulonimbus at 1,600 feet, broken clouds at 2,000 feet, broken clouds at 4,500 feet, temperature 29°C; dew point temperature 27°C, altimeter setting 1,012 hPa; trend forecast-becoming visibility 3,000 meters in thunderstorm rain; Remarks: stationary thunderstorm in the south, altimeter setting 29.89 in-Hg. (ATIS N)

SPECI at 1737 hours, wind from 280 degrees at 6 knots, wind direction variations from 250 to 320, visibility 4,000 meters in light thunderstorm rain, few clouds at 800 feet, few cumulonimbus at 1,600 feet, broken clouds at 1,800 feet, broken clouds at 4,000 feet, temperature 28°C; dew point temperature 27°C, altimeter setting 1,012 hPa; trend forecast-becoming visibility 3,000 meters in thunderstorm rain; Remarks: stationary thunderstorm in the south, altimeter setting 29.89 in-Hg. (ATIS O)

SPECI at 1741 hours, wind from 260 degrees at 7 knots, visibility 2,500 meters in light thunderstorm rain, few clouds at 800 feet, few cumulonimbus at 1,400 feet, broken clouds at 1,600 feet, broken clouds at 4,000 feet, temperature 28°C; dew point temperature 27°C, altimeter setting 1,012 hPa; trend forecast-becoming visibility 1,500 meters in thunderstorm rain; Remarks: stationary thunderstorm in the south, altimeter setting 29.89 in-Hg. (ATIS P)

SPECI at 1745 hours, wind from 260 degrees at 8 knots, wind direction variations from 220 to 280, visibility 1,200 meters in light thunderstorm rain, runway visual range 1,800 meters with downward tendency at runway 10, few clouds at 600 feet, few cumulonimbus at 1,200 feet, broken clouds at 1,400 feet, broken clouds at 3,000 feet, temperature 28°C; dew point temperature 27°C, altimeter setting 1,012 hPa; trend forecast-becoming visibility 3,000 meters; Remarks: stationary thunderstorm in the south, altimeter setting 29.89 in-Hg. (ATIS Q)

SPECI at 1749 hours, wind from 250 degrees at 8 knots gusting to 19 knots, wind direction variations from 210 to 270, visibility 1,000 meters in thunderstorm rain, runway visual range 1,500 meters with downward tendency at runway 10, few clouds at 600 feet, few cumulonimbus at 1,000 feet, broken clouds at 1,200 feet, broken clouds at 3,000 feet, temperature 27°C; dew point temperature 26°C, altimeter setting 1,012 hPa; trend forecast-becoming visibility 3,000 meters; Remarks: thunderstorm overhead, altimeter setting 29.90 in-Hg. (ATIS R)

METAR at 1800 hours, wind from 250 degrees at 8 knots gusting to

19 knots, wind direction variations from 200 to 280, visibility 1,000 meters in heavy thunderstorm rain, runway visual range 1,300 meters with downward tendency at runway 10, few clouds at 600 feet, few cumulonimbus at 1,000 feet, broken clouds at 1,200 feet, broken clouds at 2,500 feet, temperature 27°C; dew point temperature 26°C, altimeter setting 1,012 hPa; trend forecast-becoming visibility 3,000 meters; Remarks: thunderstorm overhead, altimeter setting 29.91 in-Hg, hourly precipitation 18.2 millimeters. (ATIS S)

There was no low-level wind shear warning issued, and there was no alerting message from the low-level wind shear alert system (LLWAS) around the time of the occurrence at Songshan Airport. The airport warnings that were in effect before the occurrence are as follows:

RCSS AD WRNG 1: valid from 1640 to 1740 hours, heavy thunderstorm was observed at 1640 hours with the intensity increased.

RCSS AD WRNG 2: valid from 1740 to 1840 hours, heavy thunderstorm was forecasted with the intensity remained unchanged.

The anemometer locations of the automated weather observation system (AWOS) and LLWAS of Songshan Airport are shown in Figure 1.7-3. The AWOS wind information from 1744 to 1750 hours are shown in Figure 1.7-4. From 1746:36 hours (the radio height of the aircraft was 200 feet) to 1747:36 hours (the aircraft stopped), the wind variations were 210-260 degrees and 6-10 knots for AWOS R10, the wind variations were 190-210 degrees and 6-7 knots for AWOS R28. The related LLWAS wind information is detailed in Appendix 1.

Six minutes before the occurrence, the cumulative precipitation of AWOS R10 was 5.2 mm (heavy rain), and the cumulative precipitation of AWOS R28 was 8.8 mm (heavy rain), as shown in Figure 1.7-5.

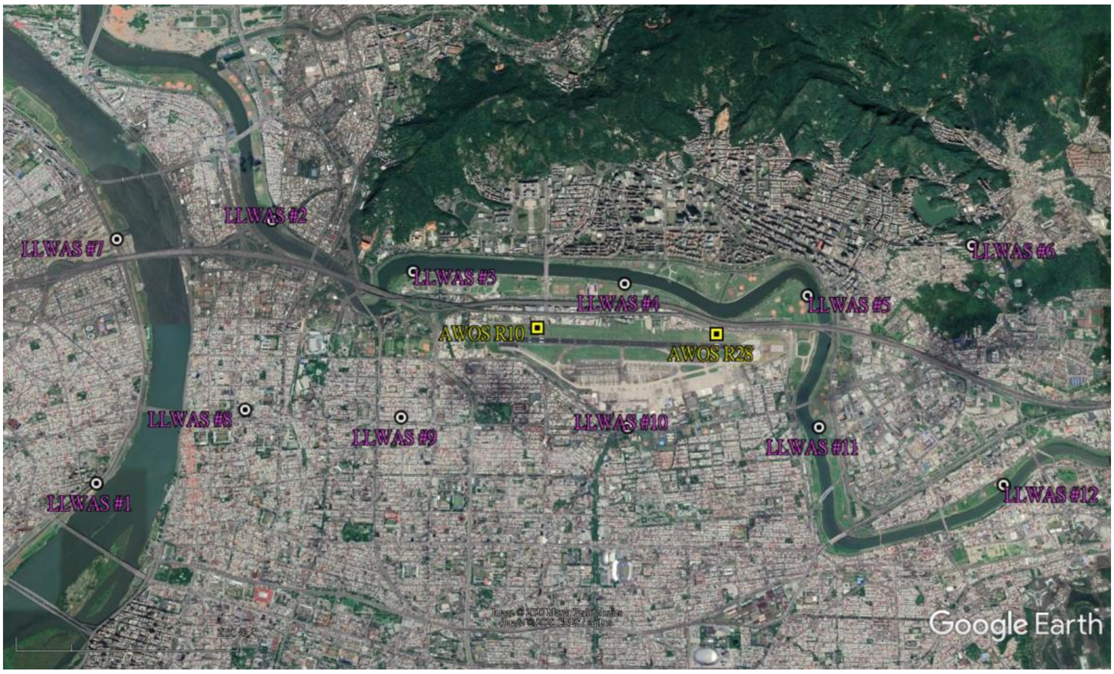


Figure 1.7-3 The anemometer locations of the AWOS and LLWAS

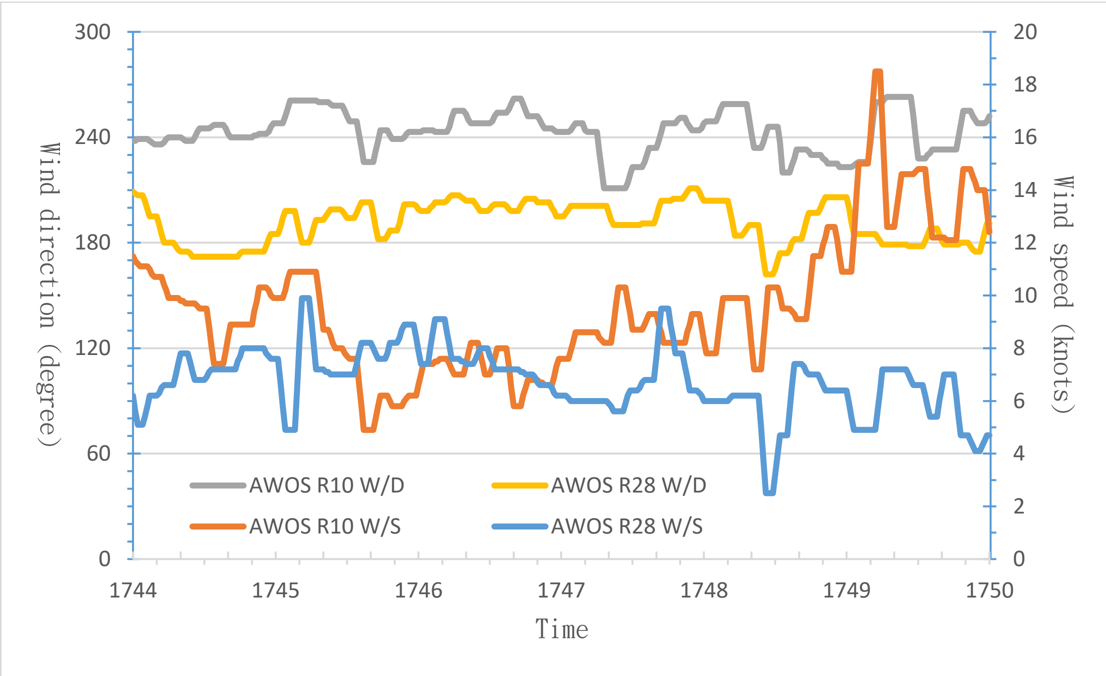


Figure 1.7-4 AWOS wind information

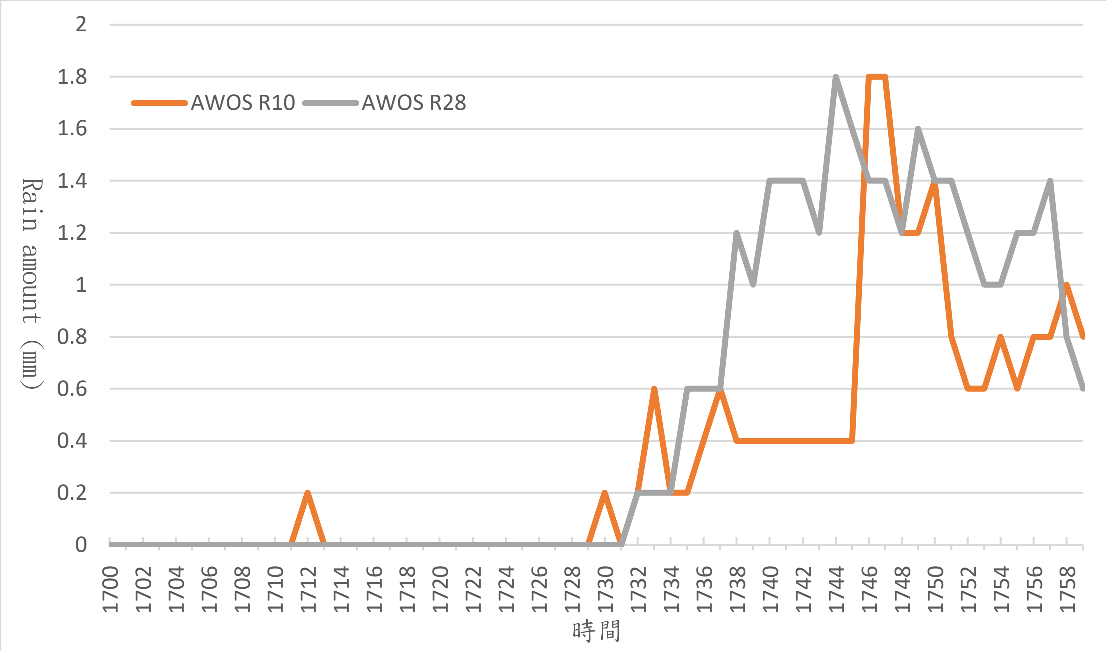


Figure 1.7-5 The rain amount of AWOS

1.8 Aids to Navigation

According to the work logs and maintenance inspection records of the Navaids Equipment Group, Taipei Aviation Facilities Sector, there was no abnormal condition in the operations of ILS on runway 10 on the day of the occurrence.

1.9 Communication

According to the air traffic control recordings, no aircraft reported the runway surface conditions or braking conditions within 1 hour before the occurrence. The ATIS broadcasts within one hour before the occurrence reported the condition of the runway surface condition as "wet".

1.10 Aerodrome

1.10.1 Airside Basic Information

According to “Aeronautical Information Publication of Taipei Flight Information Region,” Taipei/Songshan Airport is located 4.8km northeast of Taipei City with 18 feet elevation. A single runway is deployed and designated as RWY 10/28 with declared dimensions of 2,650 meters long, 60 meters wide. The runway pavement has a bituminous surface course overlaying on the plain concrete base with pavement classification number (PCN) as PCN 83/F/C/X/T. The aerodrome chart shows in Figure 1.10-1.

Base on the “As-built drawing of Songshan airport’s runway rehabilitation works” (dated 2010/1/31), both sides of the RWY 10 have a 3.5-meter shoulder. The RWY 10’s longitudinal slopes vary between -0.28% to 0.36%, with about 0.015% average and 0.33% maximum change (1060 meters away from the threshold). For transverse slopes, it varies between 1.09% and 1.50% with about 1.35% on average in the southern part of the centerline. In the northern part of the centerline, it varies between 1.23% and 1.47%, with about 1.33% on average.

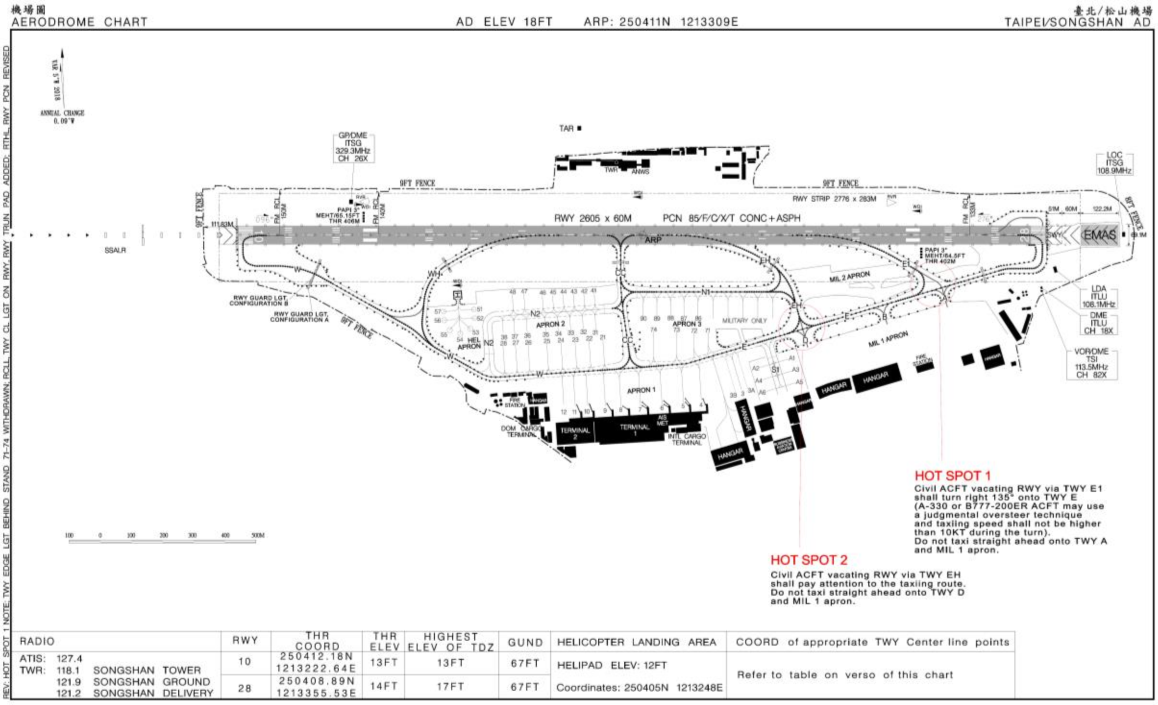


Figure 1.10-1 Taipei/Songshan aerodrome chart

1.10.2 Runway surface friction

Surface friction measurement of RWY 10/28 executes by a commissioned contractor using Grip-Tester, a continuous friction measuring equipment (CFME) that conforms to ICAO regulation. With a 1 mm depth of water sprayed on the dry runway surface, the measurement conducts with 65km/h and 95km/h along a line offsets 3 to 5 meters from the runway centerline on both sides. Whenever a one-third segment's friction value of the runway is lower than 0.53 at 65km/h, or 0.36 at 95km/h, the airport authority should plan to take corrective actions. Whenever a one-third segment's friction value of the runway is lower than 0.43 at 65km/h or 0.24 at 95km/h, the airport authority should take corrective actions immediately and issue NOTAM to warn that the runway might be slippery until the work has completed.

<u>Last measurement before the occurrence</u>

The last measurement before the occurrence was conducted on June

4, 2020. Results list in table 1.10-1 and 1.10-2.

Table 1.10-1 Last measurement results before the occurrence, 65km/h

RWY	1st 1/3 Segment	2nd 1/3 Segment	3rd 1/3 Segment	RWY
10	0.75	0.78	0.76	28
	0.75	0.75	0.73	

Table 1.10-2 Last measurement results before the occurrence, 95km/h

RWY	1st 1/3 Segment	2nd 1/3 Segment	3rd 1/3 Segment	RWY
10	0.71	0.75	0.72	28
	0.72	0.74	0.69	

The first measurement after the occurrence

The first measurement after the occurrence was conducted on July 6, 2020. Results list in table 1.10-3 and 1.10-4.

Table 1.10-3 First measurement results after the occurrence, 65km/h

RWY	1st 1/3 Segment	2nd 1/3 Segment	3rd 1/3 Segment	RWY
10	0.74	0.80	0.77	28
	0.78	0.77	0.74	

Table 1.10-4 First measurement results after the occurrence, 95km/h

RWY	1st 1/3 Segment	2nd 1/3 Segment	3rd 1/3 Segment	RWY
10	0.73	0.78	0.71	28
	0.73	0.74	0.69	

There was no rubber removal work within the interval of the measurements before and after the occurrence.

1.10.3 Related specifications for aerodrome design

Standards or recommendations about runway longitudinal slopes, transverse slopes and pavement surface in the "Aerodrome design and operations" are extracted as follows:

Longitudinal slopes

3.1.13 Longitudinal slopes

Recommendation.— The slope computed by dividing the difference between the maximum and minimum elevation along the runway centerline by the runway length should not exceed:

— 1 per cent where the code number is 3 or 4; and

— 2 per cent where the code number is 1 or 2.

3.1.14 Recommendation.— Along no portion of a runway should the longitudinal slope exceed:

— 1.25 per cent where the code number is 4, except that for the first and last quarter of the length of the runway the longitudinal slope should not exceed 0.8 per cent;

— 1.5 per cent where the code number is 3, except that for the first and last quarter of the length of a precision approach runway category II or III the longitudinal slope should not exceed 0.8 per cent; and

— 2 per cent where the code number is 1 or 2.

3.1.15 Longitudinal slope changes

Recommendation.— Where slope changes cannot be avoided, a slope *change between two consecutive slopes should not exceed:*

— 1.5 per cent where the code number is 3 or 4; and

— 2 per cent where the code number is 1 or 2.

3.1.16 Recommendation.— The transition from one slope to another should be accomplished by a curved surface with a rate of change not exceeding:

— 0.1 per cent per 30 m (minimum radius of curvature of 30 000 m) where the code number is 4;

— 0.2 per cent per 30 m (minimum radius of curvature of 15 000 m) where the code number is 3; and

— 0.4 per cent per 30 m (minimum radius of curvature of 7 500 m) where the code number is 1 or 2.

Transverse slopes

3.1.19 Transverse slopes

Recommendation.— To promote the most rapid drainage of water, the runway surface should, if practicable, be cambered except where a single cross fall from high to low in the direction of the wind most frequently associated with rain

would ensure rapid drainage. The transverse slope should ideally be:

— 1.5 per cent where the code letter is C, D, E or F; and

— 2 per cent where the code letter is A or B;

but in any event should not exceed 1.5 per cent or 2 per cent, as applicable, nor be less than 1 per cent except at runway or taxiway intersections where flatter slopes may be necessary.

Pavements

10.2.2 The surface of a runway shall be maintained in a condition such as to prevent formation of harmful irregularities.

1.11 Flight Recorders

1.11.1 Cockpit Voice Recorder

On July 9th, the investigation team received recording data from the solid-state cockpit voice recorder (CVR) installed on the occurrence aircraft from China Airlines. The 125 minutes and 19.2 seconds voice recording was determined to be either good or excellent in audio quality, and contained all flight phases including takeoff, cruise, approach, and landing roll when the occurrence occurred. The investigation team generated a CVR transcript that covered 10 minutes of recording accordingly.

1.11.2 Flight Data Recorder

On July 9th, the investigation team received data from the solid-state flight data recorder (FDR) installed on the occurrence aircraft from China Airlines. Data readout was performed per flight data map issued by the aircraft manufacturer Airbus. The FDR recording contained 26 hours, 33 minutes and 50 seconds of data and total number of recorded parameters was 1,172. While all data were based on UTC time, following is a summary on all occurrence-relevant events in local time:

1. At 1625 hours, the flight took off from Shanghai Pudong International Airport.
2. At 1743:54 hours, at barometric altitude of 2,400 ft. and radio altitude of 1,844 ft., ground spoilers were armed.

3. At 1744:40 hours, at barometric altitude of 1,760 ft. and radio altitude of 1,868 ft., autobrake setting was changed from “Low” to “Medium.”

4. At 1745:42 hours, at radio altitude of 1,001 ft., computed airspeed was 134 knots, ground speed was 152 knots, aircraft pitched 2.5 degrees nose-up, and rolled 1.4 degrees to the left. Magnetic heading was 97 degrees. Vertical rate was -800 feet/ minute. Wind speed was 14 knots at 269 degrees.

5. At 1745:59 hours, at radio altitude of 719 ft., computed airspeed was 133 knots, ground speed was 148 knots, and both autopilots were disengaged.

6. At 1746:16 hours, at radio altitude of 495 ft., computed airspeed was 130 knots, ground speed was 148 knots, aircraft pitched 1.4 degrees nose-up, and rolled 1.1 degrees to the left. Magnetic heading was 96 degrees. Vertical rate was -1,024 feet/minute. Wind speed was 14 knots at 273 degrees.

7. At 1746:49 hours, at radio altitude of 34 ft., computed airspeed was 141 knots, ground speed was 151 knots, both throttle levers were retarded from 47 degrees to zero in two seconds.

8. At 1746:54 hours, “weight on wheel” of both main gears recorded “ground” and the aircraft touched down at runway 10 of Songshan Airport. Radio altitude was zero, vertical acceleration was 1.28 g’s, and ground speed was 147 knots. The aircraft pitched 4.2 degrees nose-up, and rolls 1.1 degrees to the right. Magnetic heading was 93.9 degrees. Rudder pedal inputs ranged between 7.6 degrees and 13.6 degrees. All twelve spoilers deflected between 0.2 degrees and 4.6 degrees.

9. At 1746:55 hours, both main gears momentarily switched to air mode. Vertical acceleration ranged between 0.89 g's and 1.00 g's. Ground speed was 146 knots. The aircraft pitched 3.2 degrees nose-up, and rolled 0.4 degrees to the right. Magnetic heading was 93.2 degrees. Rudder pedal inputs ranged between 0.7 degrees and 10.8 degrees. All twelve spoilers deflected between 1.8 degrees and 10.4 degrees.

10. At 1746:56 hours, vertical acceleration reached its maximum at 1.40 g's. Ground speed was 144 knots. The aircraft pitched 2.1 nose-up, and rolled 1.4 degrees to the right. Magnetic heading was 92.8 degrees. Left sidestick recorded pitch input as -6.4 degrees, -1.7 degrees, -4.4 degrees, and -2.7 degrees respectively and roll input as -4.3 degrees, -0.8 degrees, 22.5 degrees, and -6.5 degrees respectively. Rudder pedal inputs ranged between 14.9 degrees and 15.7 degrees. All twelve spoilers deflected between 0.1 degrees and 14.9 degrees.

11. At 1746:57 hours, aircraft ground speed was 144 knots. Medium autobrake was disengaged, ground spoilers were no longer armed and autobrake fault was recorded until 1747:36 hours.

12. At 1746:58 hours, aircraft ground speed was 142 knots, three primary flight control computer (FCPC) faults were recorded. Availability status of #1, #2, #4 and #5 spoilers became null. Since then, all twelve spoilers were either recorded at stowed position or recorded invalid.

13. Between 1746:59 hours and 1747:06 hours, nose gear "weight on wheel" flipped between ground mode and air mode several times.

14. At 1747:00 hours, both throttle lever positions were recorded at -38 degrees (FULL REV); however, both thrust reversers were kept at stowed position.

15. Starting at 1747:02 hours, brake pedal inputs reached their maximum of 68 degrees in 2 seconds (left) and 4 seconds (right), and continued until the aircraft was completely stopped. Brake pressure was around 2,500 psi at 1747:36 hours.

16. At 1747:22 hours, aircraft ground speed was 81 knots, master caution was recorded until 1747:57 hours.

17. At 1747:36 hours, the aircraft stopped moving. Magnetic heading was 86.5 degrees.

During its landing roll, ground spoilers deflected momentarily. Thrust reversers did not activate at all.

Flight parameters related to this occurrence are plotted below in UTC time from Figure 1.11-1 to Figure 1.11-4. Aircraft ground track, key events, and CVR transcript are shown in Figure 1.11-5.

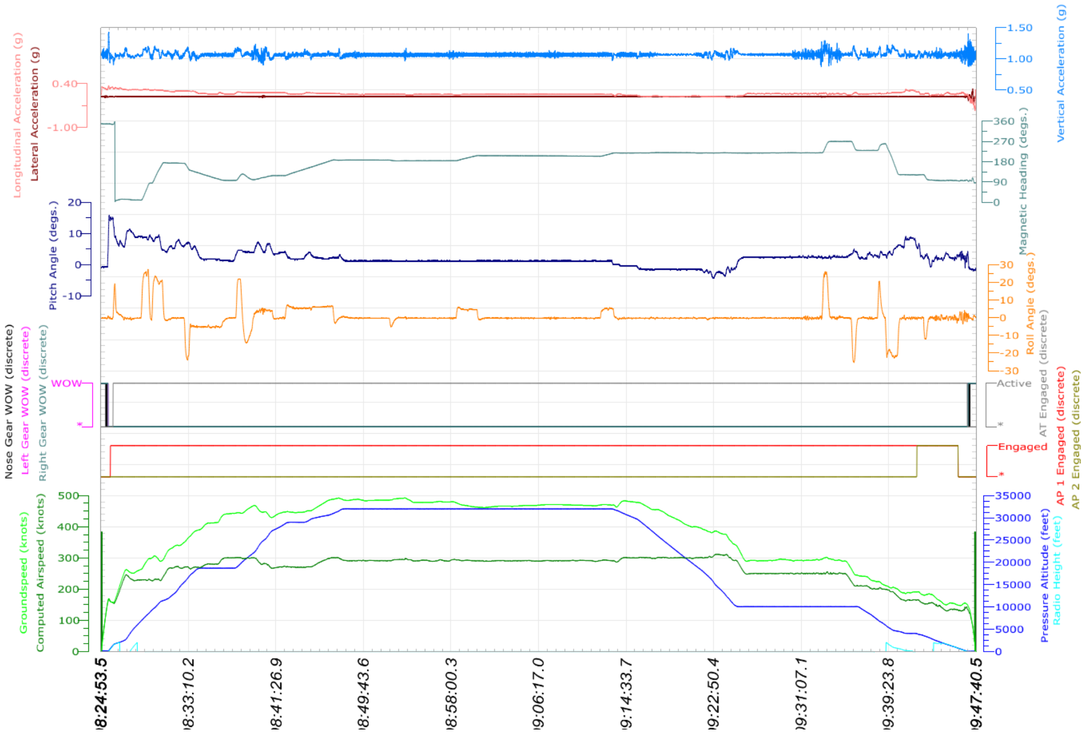


Figure 1.11-1 Plot of basic flight parameters (complete flight)

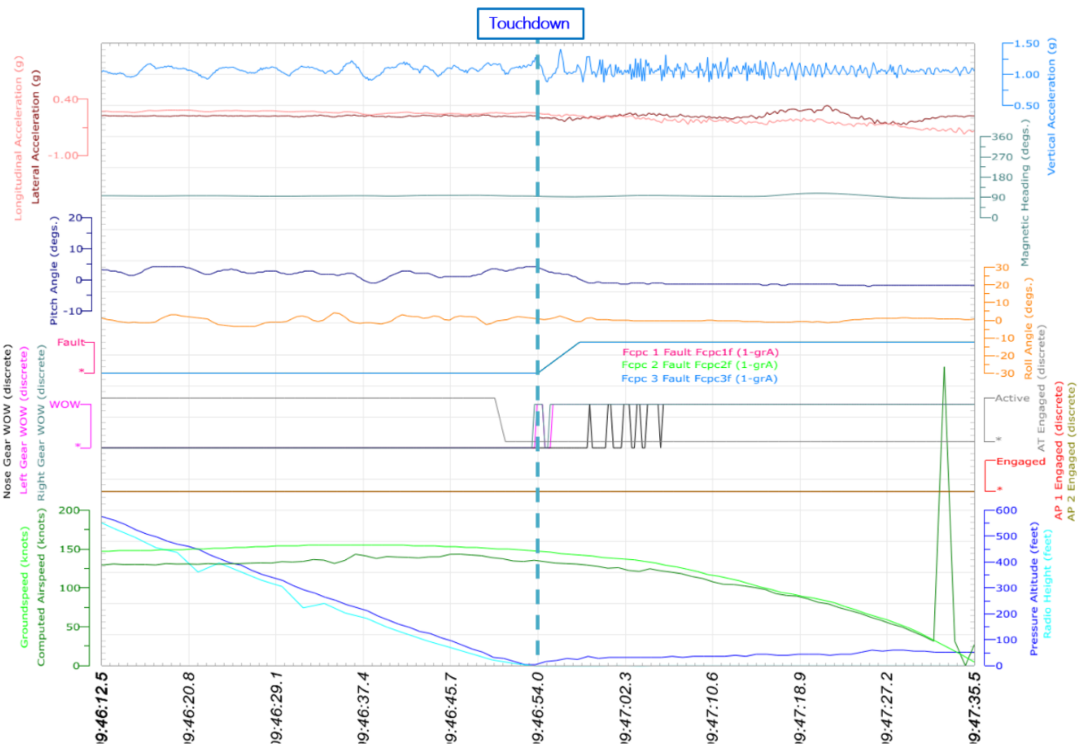


Figure 1.11-2 Plot of basic flight parameters during landing (RA<200 ft)

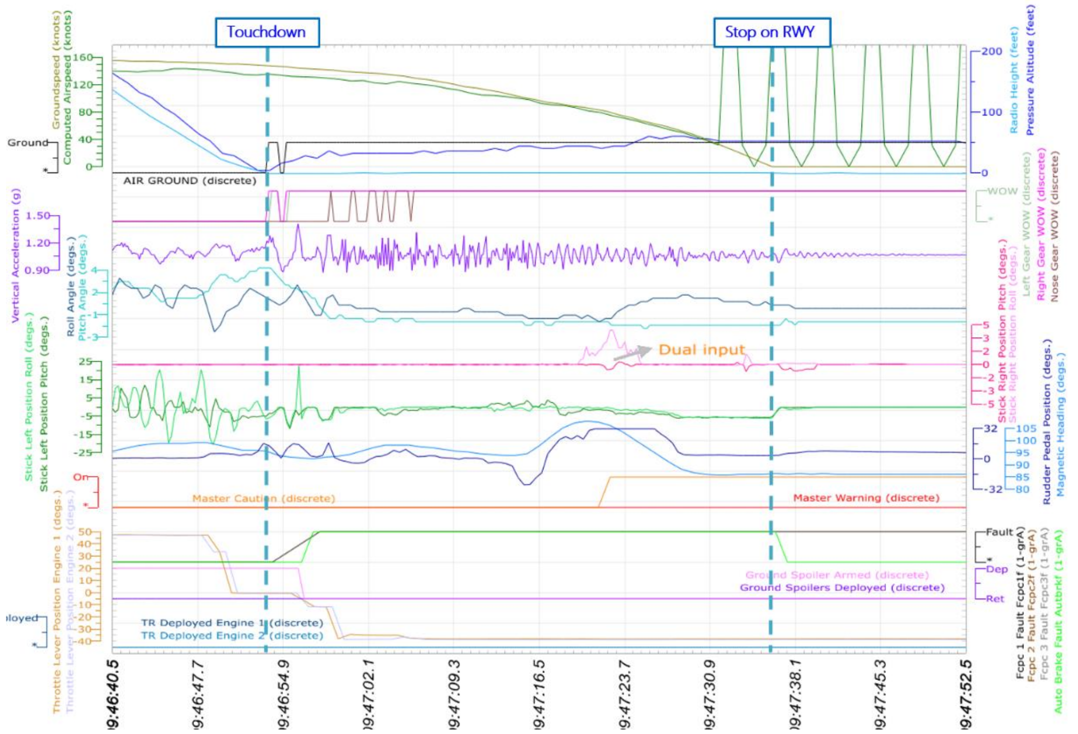


Figure 1.11-3 Plot of flight parameters related to operation during landing

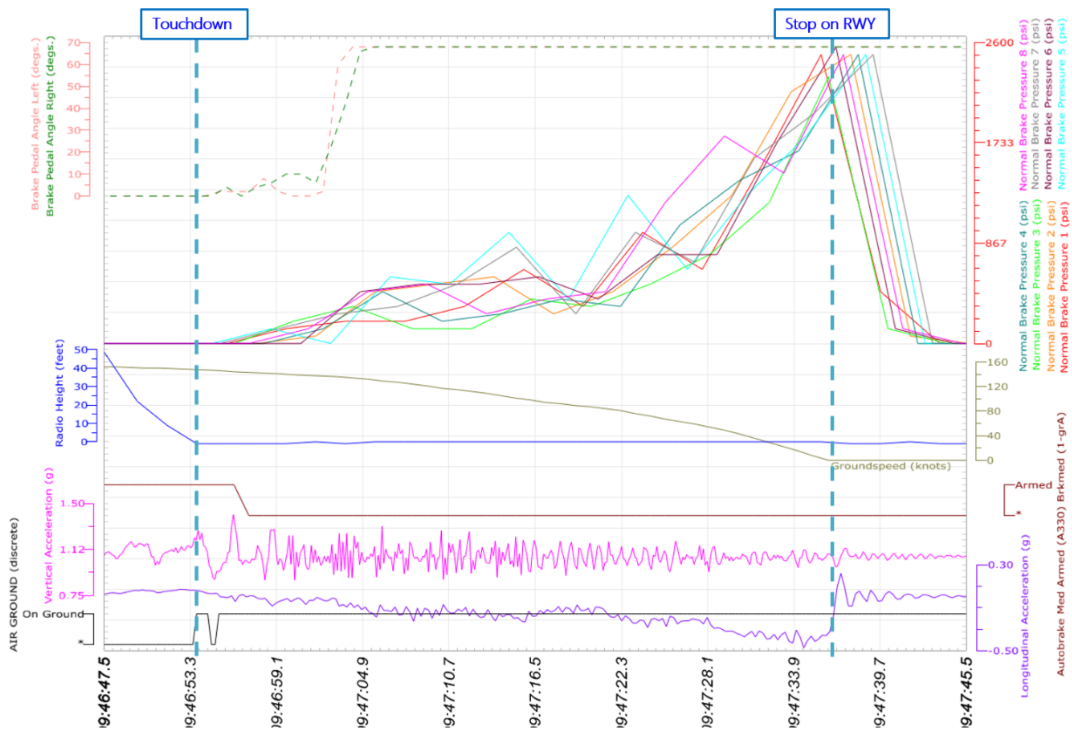


Figure 1.11-4 Plot of flight parameters related to braking during landing

No.	Local Time	CVR Transcription	No.	Local Time	CVR Transcription
0	1745:41.0	TWR: wind two five zero degrees one zero knots caution tail wind			
1	1746:55.1	CAM-2: spoiler	5	1747:02.1	CAM-2: no autobrake
2	1746:58.6	CAM-2: reverse	6	1747:04.6	CAM-1: manual brake
3	1746:59.2	CAM-1: is auto brake on	7	1747:07.2	CAM-2: reverse no green
4	1747:01.0	CAM-1: is auto brake on	8	1747:08.7	CAM-1: check quickly help me brake help me brake

Figure 1.11-5 Aircraft ground track, key events, and CVR transcript

1.12 Wreckage and Impact Information

N/A

1.13 Medical and Pathological Information

N/A

1.14 Fire

N/A

1.15 Survival Aspects

N/A

1.16Test and analysis

1.16.1 EFCS trouble shooting data

The electrical flight control system trouble shooting data (EFCS TSD) was decoded by the aircraft manufacturer as follows:

- *F200*: SAO fault (Spécification Assistée par Ordinateur (computer assisted specification)).
- *0400*：Discrepancy between COM and MON channels.
- COM fault code 0002：Rudder discrepancy between COM and MON channels.
- MON fault code 0002: Rudder discrepancy between MON and COM channels.

1.16.2 FCPC 1 shop analysis

The FCPC1 of the occurrence flight, part number LA2K2B100DH0000, serial number 2K2006366, was sent to Airbus for analysis. The shop performed the bench test and download NVM (non-volatile memory) on September 7, 2020. Airbus provided a special investigation report[3] of the FCPC1 on September 8, 2020. Following are summary and the NVM data of the report:

- *Conclusion/Actions decided: This unit is no fault found (NFF) and just requires to be cleaned. The BITE shows SAO fault at the time of the triple PRIM fault.*
- *Unit history*

  07.02.2005: TROUBLE SHOOTING DATA COM: 1200, MON: 0000 →Power supply MON replaced by OEM.
  19.02.2019: F/CTL PRIM 1 FAULT→COM FUSEMODULE REPLACED reported by EVA.

NVM data download

There were 2 fault messages stored in FCPC1 NVM as Figure 1.16-1 shows:

- 00002 ERROR: date 14/Jun/2020, F200h -> Fault SAO.
- 00001 ERROR: date 14/May/2019[4], F200h -> Fault SAO.

[3] LRU special investigation report (linked to AP5290.4), SAP repair notice number: 600128339
[4] This fault message was recorded 1 month before the event, and therefore is not related to the incident.

```
FUNCTIONAL SOFTWARE BITE ANALYSIS
==================================

         ## ERROR(s) LIST ##

00002 ERROR : F200h -> Fault SAO                          CYC : yes
   DATE : 14/06/20 HOUR : 09:46:36 TEMP : +43.0C  PWR CUT : 2248   ID : DH
   FCPC N. : 1  COUPCOUP : 5    TASK : 12   TIME : 0AC584D1h (6023.89hr)
   A/C ID : B.q83p2   PHASE : 8     FLIGHT TIME : 04BA72D9h (2644.27hr)

   VFCPC344    : 000040h - VFCPC346    : 000000h - VFCPC347    : 008000h
   CPU_STS_L1  : 0004h   - QAT1_STS    : 0000h   - QAT1_CTR_W  : 00081E0Bh
   CPU_STS_L2  : 0350h   - QAT2_STS    : 0000h   - QAT2_CTR_W  : 00001E0Fh
   DSP1_STS_L2 : 0840h   - DSP1_INFO   : 0001h   - TRR1        : B800h
   DSP2_STS_L2 : 0040h   - DSP2_INFO   : 0001h   - SEU_CPU     : 00000000h
   INFO_1/2/3  : 0000h / 0000h / 0000h           - SEU_DSP     : 00000000h

00001 ERROR : F200h -> Fault SAO                          CYC : yes
   DATE : 20/05/19 HOUR : 08:30:1e TEMP : +43.0C  PWR CUT : 320   ID : DH
   FCPC N. : 1  COUPCOUP : 1    TASK : 12   TIME : 01F09609h (1084.81hr)
   A/C ID : B.q83p2   PHASE : 4     FLIGHT TIME : 00E5ED68h (502.28hr)

   VFCPC344    : 000180h - VFCPC346    : 000000h - VFCPC347    : 008000h
   CPU_STS_L1  : 0004h   - QAT1_STS    : 0000h   - QAT1_CTR_W  : 00081E0Bh
   CPU_STS_L2  : 1350h   - QAT2_STS    : 0000h   - QAT2_CTR_W  : 00001E0Fh
   DSP1_STS_L2 : 0840h   - DSP1_INFO   : 0001h   - TRR1        : B800h
   DSP2_STS_L2 : 0040h   - DSP2_INFO   : 0001h   - SEU_CPU     : 00000000h
   INFO_1/2/3  : 0000h / 0000h / 0000h           - SEU_DSP     : 00000000h
```

Figure 1.16-1 FCPC1 NVM Error data

1.17 Organizational and Management Information

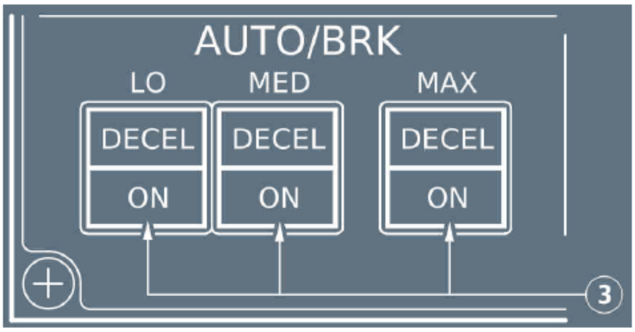
1.17.1 A330 Flight Crew Operating Manual

The version of A330 flight crew operating manual (FCOM) of occurrence flight at the time of occurrence was issued on April 16, 2020.

Some relevant paragraphs with this occurrence are shown as below:

Autobrake panel

The function, usage, timing and expected performance of the automatic brake panel are described in FCOM/Aircraft System/Landing Gear/Brakes and Antiskid/Control and Indications.



(3) AUTO BRK panel

The springloaded **MAX**, **MED**, and **LO** pushbutton switches arm the appropriate deceleration rate:

- **MAX** mode is normally selected for take off.
  In the case of an aborted takeoff, maximum pressure goes to the brakes, as soon as the system generates the ground spoiler deployment order.
- **MED** or **LO** mode is normally selected for landing.
  - When **LO** is selected, progressive pressure goes to the brakes 1 s after ground spoiler deployment order, in order to decelerate the aircraft at 1.8 m/s^2 (5.9 ft/s^2).
  - When **MED** is selected, progressive pressure goes to the brakes starting at ground spoiler deployment order, in order to decelerate the aircraft at 3 m/s^2 (9.8 ft/s^2).

ON : The **ON** light illuminates blue to indicate positive arming.
The **DECEL** light illuminates green only if the autobrake function is active and when actual aircraft deceleration corresponds to predetermined rate. (In **LO** or **MED** : 80 % of the selected rate ; in **MAX** : 2.65 m/s^2 (8.7 ft/s^2)). This occurs approximately 8 (5) seconds after activation for **LO** (**MED**) using only the brakes. Predetermined rates can also be achieved by using only the reversers or a combination of both reversers and brakes.

*Note: On a slippery runway, the predetermined deceleration may not be reached due to the slippery runway condition. In this case, the **DECEL** light will not come on, even if autobrake is active (**ACTIV** light **ON**).*

Off : The corresponding autobrake mode is not armed.

Manual Landing

The timing, procedures, techniques, and cautions of Manual Landing are described in FCOM/Procedure/Normal Procedure/Standard Operating Procedure/Landing /Manual Landing.

CHINA AIRLINES **A330-300** **FLIGHT CREW** **OPERATING MANUAL**	**PROCEDURES** **NORMAL PROCEDURES** STANDARD OPERATING PROCEDURES - LANDING

MANUAL LANDING

Applicable to: ALL

Ident.: PRO-NOR-SOP-19-A-00012003.0022001 / 16 JAN 18

FLARE

The cockpit cut-off angle is 20 °.

- **In stabilized approach, the flare height is approximately 40 ft:**

FLARE .... PERFORM | PF

Avoid flaring high. Refer to Ground Clearance Diagram.

ATTITUDE .... MONITOR | PM
THRUST levers .... IDLE | PF

If autothrust is engaged, it automatically disconnects when the pilot sets all thrust levers to the IDLE detent.
In manual landing conditions, the "RETARD" callout is triggered at 20 ft radio height, in order to remind the pilot to retard the thrust levers.

Note: *If one or more thrust levers remain above the IDLE detent, ground spoilers extension is inhibited.*

Ident.: PRO-NOR-SOP-19-A-00012004.0001001 / 08 OCT 18

AT TOUCHDOWN

DEROTATION .... INITIATE | PF

- *Lower the nosewheel without undue delay.*
- *The PM continues to monitor the attitude.*

ALL REVERSER LEVERS .... REV MAX OR REV IDLE | PF

The flight crew must immediately select REV MAX, if any of the following occurs at any time during the landing:
- *An emergency*
- *The deceleration is not as expected*
- *A failure affects the landing performance*
- *A long flare or a long touchdown*
- *An unexpected tailwind.*

A small pitch up may occur during thrust reversers deployment before nose landing gear touchdown. However, the flight crew can easily control this pitch up.
As soon as the flight crew selects reverse thrust, they must perform a full-stop landing.

CAL A330-300 FLEET — PRO-NOR-SOP-19 P 1/6
FCOM — A → — 08 OCT 18

GROUND SPOILERS .... CHECK/ANNOUNCE | PM

- *Check that the ECAM WHEEL SD page displays the ground spoilers extended after touchdown.*
- *If no ground spoilers are extended:*
  - *Verify and confirm that all thrust levers are set to IDLE or REV detent.*
  - *Set all reverser levers to REV MAX, and fully press the brake pedals.*

  Note: If ground spoilers are not armed, ground spoilers extend at reverser thrust selection.

REVERSERS .... CHECK/ANNOUNCE | PM

Check that the ECAM E/WD page displays that the reverse deployment is as expected (REV green).

DIRECTIONAL CONTROL... MONITOR/ENSURE | BOTH

- *During rollout, the PF ensures directional control using rudder pedals.*
- *Do not use nosewheel steering control handle before reaching taxi speed.*
- *During rollout, the flight crew should avoid sidestick inputs (either lateral or longitudinal).*
- *If directional control problems are encountered, the flight crew should reduce reverser thrust toward REV IDLE until directional control is satisfactory.*

BRAKES... AS RQRD | PF

- *Monitor the autobrake, if it is ON. When required, brake with the pedals.*
- *Braking may begin before the nosewheel has touched down, if required for performance reasons. However, when comfort is the priority, the flight crew should delay braking until the nosewheel has touched down.*

Note: If no ground spoilers are extended, the autobrake is not activated.

DECELERATION... CHECK/ANNOUNCE | PM

The deceleration is felt by the flight crew, and confirmed by the speed trend on the PFD.

Ident.: PRO-NOR-SOP-19-A-00012007.0001001 / 16 JAN 18

AT 70 KNOTS

SEVENTY KNOTS... ANNOUNCE | PM

ALL REVERSER LEVERS... IDLE | PF

It is better to reduce reverse thrust when passing 70 kt . However high levels of reverse thrust may be used to control aircraft speed in case of an emergency.

CAUTION	*Avoid the use of high levels of reverse thrust at low airspeed, unless required due to an emergency. The distortion of the airflow, caused by gases that reenter the compressor, can cause engine stalls, that may result in excessive EGT.*

Ident.: PRO-NOR-SOP-19-A-00012008.0001001 / 05 SEP 18

AT TAXI SPEED

ALL REVERSER LEVERS..........STOW | PF

L2 *When the aircraft reaches the taxi speed, and before it leaves the runway, stow the reversers.*

L1

CAUTION	*Except in an emergency, do not use the reverse thrust to control the aircraft speed while on taxiways.*

L2 *On taxiways, the use of reversers, even restricted to idle thrust, would have the following effects:*

- *The engines may ingest fine sand and debris that may be detrimental to the engines and airframe systems*
- *On snow-covered areas, snow will recirculate into the air inlet, and may cause an engine flameout or rollback.*

Ident.: PRO-NOR-SOP-19-A-00012010.0001001 / 16 JAN 18

BEFORE 20 KNOTS

AUTO BRK..........DISENGAGE | PF

Disengage the autobrake to avoid some brake jerks at low speed.
The flight crew should use brake pedals to disengage the autobrake.

Ident.: PRO-NOR-SOP-19-A-90000023.9000038 / 23 MAR 18

CONTROL TRANSFER

- **IF CM2 WAS PF:**
  CONTROL TRANSFER..........AS RQRD | BOTH

Standard Call Out

The timing and standard terminology used in different situations after landing are explained in FCOM/Procedure/Normal Procedure/Standard Operating Procedure/Standard Call Out/Summary for Each Phase.

CHINA AIRLINES **A330-300** **FLIGHT CREW** **OPERATING MANUAL**	**PROCEDURES** **NORMAL PROCEDURES** STANDARD OPERATING PROCEDURES - STANDARD CALLOUTS

Continued from the previous page

APPROACH AND LANDING		
Event	**PF**	**PM**
100 ft above DH/DA/MDA/MDA+50'	"CHECKED"	"ONE HUNDRED ABOVE"(2)
Visual references at DH/DA/MDA/MDA+50'	"CONTINUE"	"MINIMUM"(2)
No visual references at DH/DA/MDA/MDA+50'	"GO AROUND - FLAPS"	"MINIMUM"(2)
● **For Automatic Landing:** Between 50 ft and 40 ft RA Check FLARE on FMA At touchdown Check ROLL OUT on FMA	(If Autopilot Malfunction) "GO AROUND - FLAPS"	"FLARE"(10) (If Autopilot Malfunction) "NO FLARE" "ROLL OUT"(11)
After touchdown Ground spoilers extended REV on ED		"SPOILERS"(12) "REVERSE GREEN"(13)
Deceleration		"DECEL"(14)

Continued on the following page

CAL A330-300 FLEET PRO-NOR-SOP-90 P 11/14
FCOM ← J → 05 SEP 19

Continued from the previous page

APPROACH AND LANDING		
Event	**PF**	**PM**
At 70 kt	"CHECKED"	"SEVENTY KNOTS"

(1) Crew awareness, crew should now keep RA in scan to landing.

(2) PM monitors pin-programmed auto callout, or announces if inoperative.

(3) All altitude callouts are referenced to barometric altimeter indications.

(4) The "ONE THOUSAND" callout defines the point at which aircraft on a straight-in approach must be stabilized. 1 000 ft above TDZ is also the lowest altitude at which it is permissible to revert to higher IMC approach minimums or to correct system malfunctions prior to landing.

(5) The "CONTINUE" may be made not higher than 1 000 ft above TDZ, but may be made at any point after the "ONE THOUSAND" callout.

(6) The "UNSTABLE" callout may be made at any point below 1 000 ft above TDZ. A missed approach is mandatory after an "UNSTABLE" call.

(7) This callout is for Alert Height remind only, radio altimeter setting is not required.

(8) Check Capability.

- *CAT II:*
  "CAT II" or "CAT III SINGLE" or "CAT III DUAL"
- *CAT III a:*
  "CAT III SINGLE" or "CAT III DUAL"
- *CAT III b:*
  "CAT III DUAL"

(9) These callouts are based on equipment, not on visual reference.

(10) If FLARE is not displayed on the FMA, call "NO FLARE".

(11) If ROLL OUT is not displayed on the FMA, call "NO ROLL OUT".

(12) If the spoilers are not extended, call "NO SPOILERS".

(13) If the reverse deployment is not as expected, call "NO REVERSE ENGINE_or NO REVERSE", as appropriate.

(14) DECEL Callout means that the deceleration is felt by the crew, and confirmed by the speed trend on the PFD. If not positive deceleration, call NO DECEL.

Landing Speeds Definitions

Several speed definitions related to landing performance calculations are described in FCOM/Performance (EFB)/Landing/Landing Speeds and Distances Definitions/Landing Speeds.

CHINA AIRLINES **A330-300** **FLIGHT CREW OPERATING MANUAL**	**PERFORMANCE (EFB)** **LANDING** LANDING SPEEDS AND DISTANCES DEFINITIONS

LANDING SPEEDS

Ident.: EFB-LDG-20-00022780.0001001 / 02 OCT 19
Applicable to: ALL

LOWEST SELECTABLE SPEED (VLS)

VLS is the lowest selectable speed. VLS is used to determine the Final Approach Speed (VAPP) in normal conditions.
For more information about VLS, *Refer to DSC-22_10-50-20 Characteristic Speeds*.

REFERENCE SPEED (VREF)

VREF is equal to the VLS of CONF FULL. VREF is used to determine the Final Approach Speed (VAPP) when a system failure affects the landing performance.
For more information about VREF, *Refer to DSC-22_10-50-50 Other Speeds*.

FINAL APPROACH SPEED (VAPP)

VAPP is the speed of the aircraft when crossing the runway threshold. The flaps/slats are in the landing configuration, and the landing gears are extended.
For more information about VAPP, *Refer to DSC-22_10-50-50 Other Speeds*.

GO-AROUND SPEED

In the case of a missed approach, the go-around climb gradient is calculated at the go-around speed.
The standard go-around speed is 1.23 VS1G of the go-around configuration. For approaches with a decision height at or above 200 ft, where approach climb performance is found restrictive, the go-around speed can be increased up to a maximum limit. For more information about maximum go-around acceleration speed, *Refer to AFM/PERF-LDG Approach Climb and Landing Climb*.

Landing Distances Definitions

The definition of three different landing distances of RLD/LD/FLD are described in FCOM/Performance（EFB）/Landing/Landing Speeds and Distances Definitions/Landing Distances Definitions.

CHINA AIRLINES A330-300 FLIGHT CREW OPERATING MANUAL	PERFORMANCE (EFB) LANDING LANDING SPEEDS AND DISTANCES DEFINITIONS

LANDING DISTANCES DEFINITIONS

Ident.: EFB-LDG-20-00022782.0001001 / 02 OCT 19
Applicable to: ALL

REQUIRED LANDING DISTANCE (RLD)

The RLD is the regulatory reference to be used for dispatch landing performance computation.

The RLD is the factored certified landing distance based on:
- Maximum manual braking initiated immediately after main gear touchdown
- Prompt selection of max reverse thrust, maintained to 70 kt, and idle thrust to full stop (when credit is used)
- Antiskid system and all ground spoilers operative
- The regulatory dispatch factor.

Note: *The Required Landing Distance calculation considers the effect of the MEL/CDL items that affects the landing performance.*

IN-FLIGHT LANDING DISTANCE (LD)

The In-Flight Landing Distance reflects the performance achievable in a typical operational landing without margin.

The In-Flight Landing Distance calculation assumes:
- An airborne phase of 7 s from threshold to touchdown
- In the case of manual braking: maximum manual braking initiated immediately after main gear touchdown
- In the case of autobrake: normal system delays in braking activation
- Antiskid system and all ground spoilers operative
- Prompt selection of max reverse thrust, maintained to 70 kt, and idle thrust to full stop (when credit is used).

Note: *The In-Flight Landing Distance calculation considers the effect of the inoperative system(s) following:*
- *An MEL/CDL dispatch that affects the landing performance*
- *An in-flight failure (ECAM alert) that affects the landing performance.*

FACTORED IN-FLIGHT LANDING DISTANCE (FLD)

The definition of the In-Flight Landing Distance does not include any margin. The In-Flight Landing Distance is a realistic distance achievable in nominal conditions, i.e. the actual conditions during the landing are those used for the computation.

it is recommended to apply an appropriate margin to the In-Flight Landing Distance (either determined with or without failure) in order to cover:
- The variability in flying techniques (e.g. flare execution, delay in application of the deceleration means)
- Unexpected conditions at landing (e.g. real runway friction vs. reporting, turbulence, crosswind).

L2 The Factored In-Flight Landing Distance is defined as:
- The In-Flight Landing Distance multiplied by a Factor, or
- The In-Flight Landing Distance plus an Increment.

L1 It is the Airlines responsibility to define the margins (and their applicability) to apply on top of the In-Flight Landing Distance.
The recommended margin is a Factor of 1.15 on the In-Flight Landing Distance. Under exceptional circumstances, the flight crew may decide to disregard this margin.

Runway Condition

The definition of dry, wet and contaminated runway and the landing performance calculation are described in FCOM/Performance（EFB）/Landing/Runway Condition.

CHINA AIRLINES **A330-300** FLIGHT CREW OPERATING MANUAL	**PERFORMANCE (EFB)** **LANDING** RUNWAY CONDITIONS

DRY RUNWAY

Ident.: EFB-LDG-30-00022783.0001001 / 02 OCT 19
Applicable to: ALL

A runway is dry when its surface is not:
- Damp
- Wet
- Contaminated.

DAMP AND WET RUNWAY

Ident.: EFB-LDG-30-00022784.0001001 / 02 OCT 19
Applicable to: ALL

DAMP RUNWAY

A runway is considered as damp, when the surface of the runway is not dry, but the water on the surface does not cause a shiny appearance.

Note: *In line with the recommendations from the FAA Takeoff And Landing Performance Assessment Aviation Rulemaking Group, the applicable performance for this runway condition is GOOD and not DRY. This is not communicated via the definitions but via the RCAM.*

WET RUNWAY

A runway is considered as wet, when the surface of the runway has a shiny appearance due to a thin film of water. When this film does not exceed 3 mm (1/8"), there is no significant danger of hydroplaning.

CONTAMINATED RUNWAY

Ident.: EFB-LDG-30-00022785.0001001 / 02 OCT 19
Applicable to: ALL

A runway is contaminated when more than 25 % of its surface is covered with:
- A layer of fluid contaminant not considered as thin
- A hard contaminant.

DESCRIPTION OF FLUID CONTAMINANTS

In terms of performance, a contaminated runway is a runway covered by a fluid contaminant with a depth of more than 3 mm (1/8"). The fluid contaminant can be either:
- Dry snow
- Wet snow
- Standing water
- Slush.

Fluid Contaminants reduce friction forces, and cause:
- Precipitation drag
- Hydroplaning.

L2 Fluid contaminants descriptions:
- Dry snow is snow that, if compacted by hand, does not stay compressed when released. The wind can blow dry snow. The density of dry snow is approximately 0.2 kg/l (1.7 lb/US Gal).
- Wet snow is snow that, if compacted by hand, stays compressed when released, and with which snowballs can be created. The density of wet snow is approximately 0.4 kg/l (3.35 lb/US Gal).
- Standing water occurs due to heavy rain and/or not sufficient runway drainage. Standing water has a depth of more than 3 mm.
- Slush is snow soaked with water, which spatters when stepped on firmly. Slush occurs at temperatures of approximately 5 °C, and has a density of approximately 0.85 kg/l (7.1 lb/US Gal).

L1 DESCRIPTION OF HARD CONTAMINANTS

In terms of performance, a contaminated runway is a runway covered by a hard contaminant that can be either:
- Compacted snow,
- Ice (Cold and Dry)
- Wet ice.

Hard contaminants only reduce friction forces.

L2 Hard contaminants descriptions:
- Compacted snow: the maintenance personnel use a snow groomer to compress the snow on a runway in order to obtain a hard surface

- Ice (Cold and Dry): situation in which ice occurs on the runway in cold and dry conditions
- Wet ice: when the ice on a runway melts, or there are loose/fluid contaminants on top of the ice, the ice is referred to as "wet ice". When there is wet ice on a runway, braking and directional control are difficult or not possible, because the runway surface is very slippery.

L1 LANDING PERFORMANCE CALCULATION

L2 COMPUTATION ASSUMPTIONS

The following assumptions are considered for the calculation:
- The contaminant covers the entire length of the runway
- For fluid contaminants, the landing distance calculation does not take credit of the precipitation drag.

L1 EQUIVALENCES

In terms of performance:
- A fluid contamination is equivalent to wet, up to a maximum depth of 3 mm (1/8") of:
  - dry snow
  - wet snow
  - standing water
  - slush.
- "Frost" is equivalent to wet
- "Slippery wet" is equivalent to of 10 mm (2/5") of dry snow.

RESTRICTIONS

For maximum depth of fluid contaminants, *Refer to EFB-LDG-30 Runway Condition Assessment Matrix for Landing.*
Dispatch to a runway covered with wet ice is not permitted, unless a specific method for performance assessment has been established by the operator.
Refer to the AFM for further guidance.

RUNWAY CONDITION ASSESSMENT MATRIX FOR LANDING

Ident.: EFB-LDG-30-00022787.0003001 / 16 APR 20
Applicable to: ALL

Runway Surface Conditions		Observations on Deceleration and Directional Control	Related Landing Performance		Maximum Crosswind for Landing (Gust included)
Runway State or / and Runway Contaminant	**ESF[1] or PIREP[2]**		**Code**	**Level**	
Dry	**-**	-	**6**	**DRY**	30 kt
Damp **Wet** Up to 3 mm (1/8") of water	**Good**	Braking deceleration is normal for the wheel braking effort applied. Directional control is normal.	**5**	**GOOD**	30 kt
Slush Up to 3 mm (1/8") **Dry snow** Up to 3 mm (1/8") **Wet snow** Up to 3 mm (1/8") **Frost**					27 kt
Compacted snow OAT at or below -15 °C	**Good to Medium**	Braking deceleration and controllability is between Good and Medium.	**4**	**GOOD TO MEDIUM**	25 kt
Dry snow More than 3 mm (1/8"), up to 100 mm (4") **Wet snow** More than 3 mm (1/8"), up to 30 mm (6/5") **Compacted snow** OAT above -15 °C **Dry snow over compacted snow** **Wet snow over compacted snow** **Slippery wet**	**Medium**	Braking deceleration is noticeably reduced for the wheel braking effort applied. Directional control may be reduced.	**3**	**MEDIUM**	15 kt
Water More than 3 mm (1/8"), up to 13 mm (1/2") **Slush** More than 3 mm (1/8"), up to 13 mm (1/2")	**Medium to Poor**	Braking deceleration and controllability is between Medium and Poor. Potential for hydroplaning exists.	**2**	**MEDIUM TO POOR**	15 kt
Ice (cold & dry)	**Poor**	Braking deceleration is significantly reduced for the wheel braking effort	**1**	**POOR**	10 kt

Continued on the following page

Continued from the previous page

Runway Surface Conditions		Observations on Deceleration and Directional Control	Related Landing Performance		Maximum Crosswind for Landing (Gust included)
Runway State or / and Runway Contaminant	**ESF[1] or PIREP[2]**		**Code**	**Level**	
		applied. Directional control may be significantly reduced.			
Wet ice **Water on top of Compacted Snow** **Dry Snow or Wet Snow over ice**	**Less than Poor**	Braking deceleration is minimal to non-existant for the wheel braking effort applied. Directional control may be uncertain.	-	-	-

(1) *ESF: Estimated Surface Friction*

(2) *PIREP: Pilot Report of Braking Action*

Note: *Refer to FCOM LIM-AFS chapter for Automatic Approach, Landing and Rollout limitations.*

Dispatch Requirements

In FCOM/ Performance（EFB）/Landing/Dispatch Requirements, it explains how to calculate the RLD for dispatch and crosscheck the in-flight landing performance distance.

CHINA AIRLINES **A330-300** FLIGHT CREW OPERATING MANUAL	**PERFORMANCE (EFB)** **LANDING** DISPATCH REQUIREMENTS

GENERAL

Ident.: EFB-LDG-40-00022788.0001001 / 02 OCT 19
Applicable to: ALL

LANDING PERFORMANCE CALCULATION

The landing performance calculation is made with the landing performance (LDG PERF) application, with the computation type set to DISPATCH.

REQUIREMENT ON THE LANDING DISTANCE

The Landing Distance Available (LDA) at destination must be at least equal to the Required Landing Distance (RLD) for the planned landing weight.

REQUIREMENT ON THE GO-AROUND PERFORMANCE

The go-around climb gradient must be at least equal to:
- 2.1 %
- The gradient published in the airport approach chart.

Note: *EU-OPS requires a minimum go-around climb gradient of 2.5 % for instrument approaches with decision heights below 200 ft.*

DISPATCH ON DRY RUNWAY

Ident.: EFB-LDG-40-00022789.0001001 / 02 OCT 19
Applicable to: ALL

Landing performance is calculated without the benefit of thrust reversers, as per regulation.
L2 For information, the AFM publishes the autoland landing distance increments on dry runways.

DISPATCH ON WET RUNWAY

Ident.: EFB-LDG-40-00022790.0001001 / 02 OCT 19
Applicable to: ALL

Landing performance is calculated without the benefit of thrust reversers, as per regulation.
The RLD for a wet runway is the RLD for the dry runway multiplied by 1.15.

DISPATCH ON CONTAMINATED RUNWAY

Ident.: EFB-LDG-40-00022791.0001001 / 02 OCT 19
Applicable to: ALL

Landing performance can be calculated with the benefit of the thrust reversers.
For operators complying with EU-OPS regulation, the landing weight on a contaminated runway cannot exceed the landing weight on a wet runway.

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DISPATCH WITH MEL OR CDL ITEM

Ident.: EFB-LDG-40-00022792.0001001 / 02 OCT 19
Applicable to: ALL

The aircraft can be dispatched with deferred MEL or CDL items. In this case, the LDA must be at least equal to the RLD calculated with the applicable MEL or CDL item selected.

MEL or CDL items that affect landing performance are:
- MEL items that reduce braking capabilities (brakes, spoilers, thrust reversers if applicable)
- MEL items that have an impact on thrust available for go-around (engine anti-ice valve stuck open)
- CDL items that increase aircraft drag (seals, fairings).

L2 CDL items are divided in two categories: negligible and non-negligible items.
If the number of negligible CDL items is less or equal to three, no penalty applies.
If the number of negligible CDL items is more than three, a drag increase for each item is applied.

IN-FLIGHT LANDING DISTANCE CROSSCHECK

Ident.: EFB-LDG-40-00022793.0001001 / 02 OCT 19
Applicable to: ALL

The Factored In-Flight Landing Distance may, in some cases, and in particular on contaminated runway, exceed the RLD considered at dispatch.
When arrival conditions are expected to be marginal it is recommended to make a preliminary calculation of In-Flight Landing Distance or Factored In-Flight Landing Distance at dispatch in order to nominate suitable destination alternates.
The landing performance calculation may also check that the aircraft can land at destination in compliance with In-Flight Landing Distance.
In this case, the landing distance considered for dispatch is the maximum of the RLD and the Factored In-Flight Landing Distance.

In-Flight Performance Assessment

The calculation method and relevant consideration of in-flight landing performance computation are described in FCOM/Performance（EFB）/Landing/In-Flight Performance Assessment.

CHINA AIRLINES **A330-300** **FLIGHT CREW OPERATING MANUAL**	**PERFORMANCE (EFB)** **LANDING** IN-FLIGHT PERFORMANCE ASSESSMENT

GENERAL

Ident.: EFB-LDG-50-00022795.0001001 / 02 OCT 19
Applicable to: ALL

During flight, the flight crew performs a landing performance computation if the landing conditions changed compared with the landing performance computation at dispatch, or with a previous computation (e.g. runway, weather conditions, in-flight failure affecting performance, diversion).
The landing performance calculation is made with the landing performance (LDG PERF) application, with the computation type set to IN-FLIGHT.
The landing distance used for this computation is the Factored In-Flight Landing Distance (FLD). The flight crew uses the RCAM to determine the runway landing performance and code.
If the aircraft has been dispatched with deferred MEL or CDL items, the In-Flight Landing Distance and Factored In-Flight Landing Distance must be calculated with the applicable MEL or CDL items selected.
Under exceptional circumstances, the flight crew may decide to disregard the Factored In-Flight Landing Distance. In this case the flight crew must check that the In-Flight Landing Distance is shorter than the LDA at the destination or diversion airport.

L2 For more information on In-Flight Landing Distances, *Refer to EFB-LDG-20 Landing Distances Definitions*.

LANDING PERFORMANCE WITHOUT IN-FLIGHT FAILURE

Ident.: EFB-LDG-50-00022796.0001001 / 02 OCT 19
Applicable to: ALL

LANDING PERFORMANCE CALCULATION

The flight crew enters the expected landing conditions and calculates the landing performance.

FLAPS LEVER POSITION

The FLAPS lever position for landing is at flight crew's discretion.

VAPP DETERMINATION

VAPP is calculated by the FMS and is displayed on the APPR panel of the FMS PERF page.

L2 The VAPP is calculated by the FMS as the maximum of:
- VMCL + 5 kt
- 1.23*VS1G + APPR COR

  APPR COR is the highest of
  - 5 kt in case of A/THR ON
  - 5 kt in case of Ice Accretion
  - 1/3 Headwind component (excluding gust - maximum 15 kt).

LANDING PERFORMANCE FOLLOWING IN-FLIGHT FAILURE

Ident.: EFB-LDG-50-00022798.0001001 / 02 OCT 19
Applicable to: ALL

LANDING PERFORMANCE ECAM INDICATIONS

After an aircraft system failure that occurs in flight, the flight crew follows the associated ECAM procedure.
When required, the ECAM displays landing performance indications in the applicable procedure.
The ECAM alert items are displayed on the ECAM STATUS page. The ECAM displays LDG DIST PROC APPLY if an ECAM alert item affects landing performance.

LANDING PERFORMANCE CALCULATION

The flight crew enters the ECAM alerts item that affect performance and expected landing conditions in the LDG PERF application to calculate the landing performance.

FLAPS LEVER POSITION

The flight crew selects the FLAPS lever position requested by the ECAM.

Note: *If there are no ECAM instructions, the FLAPS lever position for landing is at flight crew's discretion.*

VAPP DETERMINATION

- **If the ECAM displays LDG DIST PROC APPLY:**
  The flight crew enters into the FMS - PERF - APPR page the VAPP value computed by the LDG PERF application.

LDG INHIBIT

The flight phases of “LDG INHIBIT” are described in FCOM/ Aircraft System/Indication and Recording System/Indication on EWD/Flight Phases.

FLIGHT PHASES

Applicable to: ALL

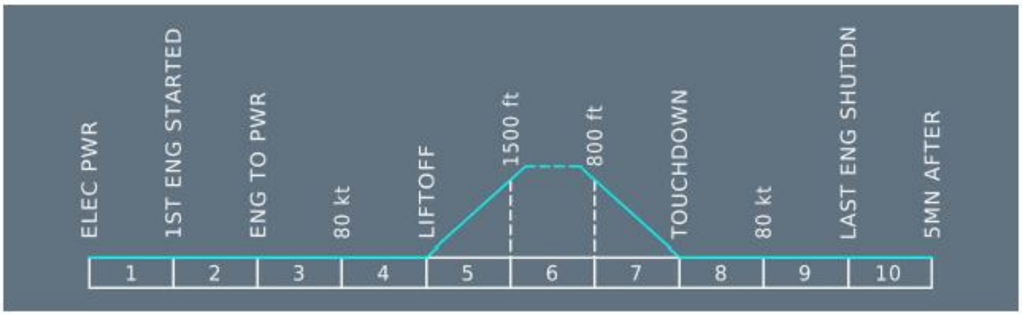
Ident.: DSC-31-15-B-00000484.0001001 / 16 JAN 18

GENERAL

The **FWC** divides its functions according to these ten flight phases:

CAL A330-300 FLEET DSC-31-15 P 3/8

FCOM C to D → 05 SEP 19



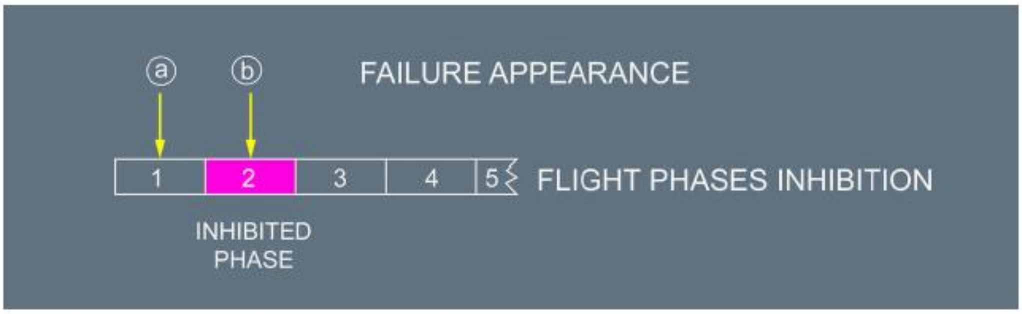
To improve its operational efficiency, the computer inhibits some warnings and cautions for certain flight phases. It does so to avoid unnecessarily alerting the pilots at times when they have high workloads (such as takeoff or landing). In these two phases, the DU displays magenta memos: "T.O. INHIBIT" (flight phases 3, 4, and 5), and "LDG INHIBIT" (flight phases 7 and 8).

<u>Note:</u> *These flight phases are different from, and independent of, the ones used by FMGEC.*

Ident.: DSC-31-15-B-00004743.0001001 / 16 JAN 18

FLIGHT PHASE INHIBITION

Two cases are possible (for instance) :



Effect on E/WD :

(a) The failure occurs during Phase 1. The E/WD immediately displays the warning and continues to display it as long as the failure is present, even in Phase 2.

(b) The failure occurs during Phase 2. The E/WD only displays the warning once the aircraft has entered Phase 3, where it is not inhibited. Then, the warning remains displayed as long as the failure is present.

1.17.2 In-flight landing performance computation

RCSS ATIS information L: ”RWY 10 280/3 260V320 7000M – TSRA FEW1400 FEW CB1400 BKN2500 BKN5000 29/27 QNH 1011” was used for landing performance computation with autobrake “LO” Runway condition “Good”. The Landing Distance was 7,117 feet and the Factored Landing Distance was 8,185 feet; the margin to the runway end was 362 feet (Landing Distance Available [LDA] was 8,547ft), as shown in Figure 1.17-1.

Figure 1.17-1 In-flight landing performance computation

1.18 Additional Information

1.18.1 Summary of Interview

1.18.1.1 Summary of Interview with Captain

The PF stated that the company has classified Songshan Airport as a special airport and it must be that the captain performs the take-off and landing procedures. The flight CI201 from RCSS to Pudong (ZSPD) was normal, and the status of the returning flight CI202 from ZSPD to RCSS was normal as well. Before commencing the CI202 flight duty, the flight crew reviewed the relevant pre-departure briefings, dispatch inspections, and examined the deferred defect logbook (DD)/Technical Log Book (TLB) records, no maintenance anomalies found.

Before reaching the descent point, the flight crew carried out the approach briefings by following the company's procedures, including checking on the Threat & Error Management (TEM) Guide, crew qualifications, airport environment, equipment, and descending procedures. The communication with the ATC was also normal. The ILS approach was used on that day. The PF particularly reminded the PM about the situation of the glide slope, asking him to pay attention to the PAPI after DA, also highlighted CFIT/ALAR, stable approach criteria, and airport route profiles, etc. because nature of the RCSS is a special airport.

There were no anomalies of the flight during descend and approach phases. When performing the touchdown, the PM called out "spoiler", which was the standard callout, and the PF then immediately operated the reverser to its full position and started to notice the anomalies. The aircraft did not decelerate and there was no sound response from the reverser. At this time, the PF found that the medium autobrake setting was not valid, which should be effective upon the touchdown, and no deceleration rate was observed either.

Once the PF confirmed that the autobrake function was invalid and the deceleration rate was very slow, he immediately applied the manual brake to its full maximum. He then asked the PM to assist stepping on the brake pedal so as to bring the aircraft to a complete stop.

The PF recalled that the nose of the aircraft was facing the centerline of the runway after stopping and the heading was 096 degrees, which was too close to the end of the runway to make turns. The Songshan Tower advised them that the front wheels of the aircraft were about 10 meters from the end of the runway.

The flight crew decided to request a tow tractor to move the aircraft to the apron for safety reasons, while the tower requested to shut down both engines so that the tow tractor could go underneath the aircraft.

The ECAM was checked on the way of the aircraft being towed back to the apron, and found that the ECAM procedures were performing normally. The company manual states that when the aircraft is stable and the flight path is higher than 400 feet, the ECAM action can be performed under the condition of a stable approach path and normal procedures completed, by engaging autopilot, accessing ECAM Action and performing a cross check.

The aircraft then stopped on the runway and in a standstill status. The maintenance staff was there to troubleshoot the ECAM defects, and the PF logged the ECAM defects in the TLB.

The PF recalled that the first page of ECAM was “Flight Control Protection Lost”, and the next page was PRIM1/PRIM2/PRIM3 fault. Regarding the calculation of landing performance, the PF stated that he tended to be conservative on the calculations.

At that time, the ATIS showed 3 knots downwind, but for the sake of increasing the braking allowance, the PF used 5 knots-downwind to calculate instead and set the autobrake to low. In the latter phase of descent, he got report from ATC that the visibility reduced to 2,500 meters. At the same time, he also noticed that the Navigation Display (ND) showed a change in wind direction and learned that the weather had changed, so he changed the autobrake setting from “low” to “medium”. The landing distance calculated from the EFB (electronic flight bag) was about 5,000 to 6,000 feet, the factored landing distance was the landing distance plus 15%, therefore, there should be quite a few of runway remaining.

The PF recalled that the PM called out “spoiler” when the aircraft making the touchdown. After confirming there was a SPOILER on the display, he started to pull the reverse to idle and then to max. Since the PF did not feel the deceleration rate, nor the effect of the reversing airflow, nor the obvious noise from the reverser operation, he deemed the autobrake was malfunctioning. While using the manual brake operation, he noticed that the deceleration rate was very abnormal, so stepped on the brake pedal all the way. As for a passenger flight consideration, the braking was exercised in a gradually pressure-building manner. As the PF found that the deceleration rate was unusual, he then stepped on the pedal fully and asked the PM’s help to step. The PF discovered later that three FCPCs were faulty. As the three FCPCs had failed, the reversers, autobrake, and ground spoiler became invalid.

The PF stated that hydroplaning conditions may have existed at the time of the landing because of heavy rain, but without further evidence. After the three FCPCs failed at the same time, all the spoilers were retracted, and it would have a significant impact on the deceleration, resulting in a very inefficient deceleration at high speed. As for a potential involuntary disconnection of the A/BRK by the flight crew, according to the PF, both the PF and the PM did not have such experience and would not have done so this time either.

1.18.1.2 Summary of Interview with FO

The day before the flight the First Officer (FO) was off duty at home, the daily routines and sleep quality were normal. He got up at 8 a.m. on the occurrence day, arrived at company at 10 a.m. and took a taxi to Songshan Airport (RCSS). The report time was 11 a.m. the crew follow the procedures to complete the preflight briefing and conduct the CI-201 flight. The entire flight to Pudong Airport (ZSPD) were normal.

The FO was as the pilot-monitoring (PM) and the Captain was as the pilot-flying (PF) from Pudong back to Songshan (CI-202). All preflight task were all follow the procedures. The took-off, departure, cruise, descent and approach phases were all normal. The aircraft systems worked properly during the period. The crew conducted the approach briefing in accordance with SOP.

As for performance calculations, the crew first refer to ATIS data. If ATIS changes significantly, they will recalculate it based on the changes. They considered the tail wind for this landing and conservatively calculated the landing distance, set the autobrake to LOW and make sure the runway length was suitable and the aircraft can safely land. They also did the double check afterward.

During the approach, the ATC informed that the visibility dropped to 2,500 meter (from 7000 meters) and the wind changed to tail wind, so the captain decided to set the autobrake to MED, and the PF instructed FO should monitor the spoilers after touchdown. The aircraft functioned normally and the flight conditions met the stable approach criteria before landing. The FO checked spoilers extended after touchdown and called out “spoiler”, then turned his attention to monitor if the reverser is activated. FO observed the reversers were not activated, he call out “reverser” once again, and continued to monitor it but the reversers were still not activated. The PF asked FO if autobrake was working. FO checked the autobrake, found that the indicator was off and reported it immediately. The PF immediately applied manual brake afterward and asked FO to help step on the brake. The FO step on the brakes and focus on the direction control but he felt that the deceleration was slow. The FO continued to apply the brakes until the plane stopped near the end of the runway. After the crew discussed the situation, they decided to request the tow cart to tow the aircraft back to the bay, and then they shut down the engines and the aircraft was towed to the bay.

As the PM recalled, during the approach and landing phases, the captain did emphasize the spoiler and the reverser activities who instructed the FO to call out the status of spoiler in time after aircraft touchdown. After touchdown, the FO did see six green triangles and callout “spoiler” but no "reverser" appeared after that, so he called “reverser” twice to remind the PF to activate the reverser. The reason the FO called twice because he thought the PF did not activate the reverser. In fact, the PF had already done it, so it might be mechanical failure. Then the crew both found that the autobrake did not work, so the PF used manual brake and asked the PM help to step on the brake.

The mission’s briefings including the ECAM system, diversion fuel, one ZULU arrival, landing on runway 10, airport taxi path, landing performance data calculations, the automation system, and low-visibility had been done following the training manual.

The PF and the PM did the landing performance calculations following the data provided by the ATIS, which was consistent with the performance data of operation. The PF used a relatively larger tailwind calculation for setting autobrake to land normally and safely.

By the time the PM helped to step on the brake, he felt that the brake pressure was normal, but the deceleration was not as good as expected. He also called out "centerline" because he wanted to make sure that the aircraft was kept on the centerline. During the landing phase, not until the PF asked the PM to apply the brake, the PM only put his foot on the rudder but did not put any pressure on it.

1.18.2 Manufacturer's analysis and conclusions

Airbus provided analysis report[5] with related to three FCPCs failed at touch down on February 12, 2021. The in-service experience, root cause analysis and conclusion are quoted as follows:

In-service experience

Following the occurrence, Airbus reviewed its in-service experience, and confirmed that no other triple PRIM fault at touchdown event had been reported on A330/A340 aircraft family since entry into service. The A330/A340 fleet fitted with electrical rudder has accumulated 8.7 millions of Flight Cycles and 44.3 millions of Flight Hours (in-service data from April 2020).

In addition, Airbus also reviewed the 2 years (2019 and 2020) of PFR data available within its Skywise open data platform, which regroups around half of the total Airbus fleet. No similar triple PRIM fault event was found.

Root cause analysis:

The DFDR analysis did not highlight any abnormal behavior of the

[5] China Airlines, A330 MSN607, B-18302 Loss of 3 PRIM at touchdown, 14 June 2020, Airbus Report, Reference: WI 420.1097/20, date: 12 February 2021

flight control surfaces, and in particular of the rudder, which movement was consistent with the rudder pedals inputs. The FCPC1 examination confirmed that the unit's hardware was NFF, and therefore not the cause of the event. The PRIM software specification was then reviewed to understand what could be the source of an undue triggering of the COM/MON monitoring on the rudder, at touchdown.

At touchdown, a flight to ground transition occurs within the flight control laws. Specifically for the yaw axis, in flight mode, the rudder pedal order is filtered, whereas in ground mode, the rudder pedal order is unfiltered. Therefore, at the flight to ground transition, the rudder order will linearly change from the filtered flight law to the unfiltered ground law, in both COM & MON channels. As depicted below, a pedal push shortly before touchdown, followed by pedal release between touchdown and detection of ground condition by both channels will result in a difference between COM & MON rudder orders during the transition, due to the asynchronism between both channels.

This difference in COM & MON rudder orders will depend on:

- The value of the asynchronism: the higher the asynchronism, the higher the difference, for a given rudder order.

- The dynamic of the rudder order: to generate the highest difference, rudder order shall be inverted at ground impact.

Following the review done on the software specification, it was identified that:

- If the asynchronism in one PRIM was high at time of touchdown, then there was a risk of single PRIM fault at touchdown, when combined with a rudder pedal order inversion at the ground transition.

- Should the asynchronism be high concomitantly in the 3 PRIM, again combined with a rudder pedal order inversion at the ground transition, there was a risk of triple PRIM fault at touchdown.

Conclusion

On 14th of June 2020, the A330 MSN607 (registered B-18302) operated by China Airlines (CAL) experienced the loss of the three Flight Control Primary Computers (FCPCs) at touchdown, during landing at Taipei Songshan airport. The aircraft reconfigured on the Flight Control Secondary Computers (FCSCs), in flight control direct law.

As a consequence of the three FCPCs loss, the non-release of the independent locking system prevented the reversers' deployment and the ground spoilers were cancelled, resulting in increased landing distance. Moreover, the autobrake system was lost. The normal braking system (i.e. with anti-skid) was available; adhering to the landing SOP, the crew applied maximum manual braking to stop the aircraft.

The root cause of this event was determined to be an undue triggering of the rudder order COM/MON monitoring concomitantly in the 3 FCPC. The robustness of this monitoring will be improved in the future A330 FCPC standards. Meanwhile, relevant operational procedures have been reminded to all affected operators.

1.18.3 Sequence of Events

Table 1.18-1 presents the sequence of events for the occurrence flight, which is based on the information of interviews, ATC transcripts, CVR transcripts, and FDR data.

Table 1.18-1 CI202 Sequence of Events

Local Time	Events	Source(s)
1625	CI202 took off from Shanghai Pudong Intl' Airport	FDR
1647:50	CI202 changed cruising altitude (FL 320)	FDR
1658:53	Flight crew radio contacted with North sector of Taipei Area Control Center	ATC
1653 | 1700	Flight crew performed descent preparation and the approach briefing. A/C in-flight landing performance analysis set ”*runway condition wet/good*”	CVR interview
1713:15	A/C started descending altitude	FDR
1725:46	Flight crew radio contacted with Taipei Approach Control Tower, and received QNH setting 100 mbar of runway 10 of Songshan airport.	ATC
1740:37 | 1740:44	The Captain recognized raining condition near Songshan airport. CAM-1”*songshan is rainy too request weather*	CVR
1741:36 | 1741:38	Flight crew discussed light thundershowers CAM-1(PF)”*is it rainy*” CAM-2(PM)”*light thunder shower rain*”	CVR
1741:45	Flight crew received an ILS approach clearance for runway 10 of Songshan airport	CVR
1743:21	At altitude of 3,008 ft, Tower controller informed the airport's visibility degraded to 2,500 meters, and provided surface wind and QNH information for flight crew. “*runway one zero wind two four zero degrees seven knots QNH one zero one two the visibility two thousand five hundred meters with light thunder storm and rain continue approach*”	CVR
1743:50	Tower controller issued a landing clearance, and provided surface wind 250 degrees 9 knots. “*runway one zero wind two five zero degrees niner knots caution tailwinds clear to land* “	CVR
1744:28	Flight crew started to perform landing checklists. “*autothrust, autobrake medium, landing no blue*”	CVR
1744:37	Flight crew changed autobrake setting from “LO” to “MED”	CVR

1744:43	Flight crew finished landing checklists, no ECAM fault message.	CVR/FDR interview
1745:41	Tower controller provided surface wind and QNH information “*wind two five zero degrees one zero knots caution tail*	CVR
1745:47.	PF requested PM ”*wipers could be faster it would be all right*”	CVR
1745:58	CAM-2 “*okay approach light ahead*” PF disengaged the auto pilot FDR recording – RA 773 ft, CAS 133 kt, GS 148 kt, wind 272 degrees 11 kt.	CVR FDR
1746:41	PM reminded PF to maintain the runway centerline. CAM-2”*center line*”	CVR
1746:47.7	EGPWS auto call-out sound” *fifty*” FDR recording –CAS 142 kt, GS 152 kt, wind 240 degrees	CVR FDR
1746:49 | 1746:53	CI202 de-rotation operation FDR recording – RA from 34 ft descend to 3 ft; continuing left-rudder pedal input between 3 degrees to 16 degrees. At RA 15 FT, both engine throttle levers were on ”retard” position	FDR
1746:54 1746:55	CI202 first touched down of main landing gear; after 1.5 sec later, second touched down. PM called out” *spoiler*” PF responded ”*check*”	FDR CVR
1746:58 1746:59	FCPC 1, 2, 3 FAULT Ground spoilers did not deployed; autobrake did not activated PM” *reverse*” PF” *is autobrake on*”	FDR CVR
1747:01 | 1747:02	PF” *is autobrake on*” PM” *autobrake not activated*” both engine throttle levers were at”-38 degrees” position both engine thrust reversers were not deployed	CVR FDR
1747:04	PF” *manual brake*” FDR recording- GS 134 kt	CVR FDR

1747:07 | 1747:08	PM" *reverse no green*" PF" *check quickly help me brake help me brake*" PF interview mentioned that "*applied full brake, deceleration is very abnormal*"	CVR interview
1747:22	（single chime） FDR recording- GS 81kt	CVR FDR
1747:37 | 1747:56	PM reported to the tower controller CAM-2"*dynasty two zero two step stop on runway*" CAM-2"*dynasty two zero two stop on the runway we need a tow car*" CAM-2"*affirmative uh we need a tow car and we stop on the runway*" Nose wheel was located at 9.1 meters from the end of runway 10.	CVR interview
1748:32	PF informed the tower controller CAM-1"uh we just uh due to performance uh and runway condition we just stop end of the runway now we think we uh not able uh vacate runway by ourselves"	ATC CVR

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Chapter 2

2.1 General

The occurrence flight crew were holders of valid airman certificates and medical examination certificates issued by the Civil Aeronautics Administration (CAA) Taiwan. The qualification of flight crew has no issue. There was no abnormal finding from the pilot training and check records related to this occurrence. The rest and activities of the flight crew were normal within 72 hours before the occurrence. There were no evidence indicating the performance of the flight crew were influenced by medical, drugs, and alcohol factors during the occurrence.

The weather condition at Songshan Airport at time of the occurrence was within the limits of the occurrence aircraft. The weight and balance of occurrence flight was within limits. Following issues will be discussed in this chapter,

- Airworthiness/ flight control system,
- FCPC failure analysis
- Stable approach and manual landing
- Factored landing distance margin analysis
- Long landing additional risk
- Runway conditions and airplane deceleration performance

2.2 Airworthiness and Flight Control System

A review of the technical log book (TLB) and deferred defect log book of the occurrence aircraft indicated that there were no defects reported under the minimum equipment list (MEL), or deferred defects when the flight was dispatched from Pudong Airport. Reviewing 3 months maintenance records before the occurrence there was no anomaly records. A review of the occurrence aircraft's airworthiness directives (ADs) and technical service bulletins (SBs) indicated that they were in compliance with applicable standards.

The FDR, CVR, TLB and PFR indicated that 3 FCPC fault at touchdown and ground spoilers, autobrake, thrust reversers not function properly during landing roll. These malfunctions are discussed as follows:

According to the TLB records and PFR, the reported defects including “AUTO BRK INOP AFT TOUCH DOWN”, “THR REV FAULT (INOP) AFT LDG TOUCH DOWN”, “F/CTL PRIM 1, 2 & 3 FAULT AFT LANDING” and “F/CTL DIRECT LAW （PROT LOST） AFT L/D”. The summary of maintenance actions performed to each defects as follows,

- Reported defect: AUTO BRK INOP.

Maintenance action: Performed Brake System Control Unit BITE test, result normal.

- Reported defect: THR REV FAULT (INOP).

Maintenance action: Replaced FCPC1 and Operational test normal, land CAT III capability test normal.

- Reported defect: F/CTL PRIM 1 fault、PRIM 2 fault、PRIM 3 fault and F/CTL DIRECT LAW

Maintenance action: Replaced FCPC1 and Operational test normal, land CAT III capability test normal.

Above mentioned maintenance actions indicated that the autobrake system is normal. According to AMM 32-42-00-00, to arm and engage the automatic braking mode, the BSCU requires two serviceable flight-control primary computers (FCPCs) available. Based on this requirement, the autobrake could not be engaged due to all 3 FCPCs fault at touchdown.

The maintenance action for thrust reverses fault indicated that thrust reversers system had no issue. The non-deployment originated from the FCPC's fault. According to FCOM DSC-70-70, the actuation logic for thrust reverser deployment requires: (1) One FADEC[6] channel that operates with its associated throttle reverse signal, (2) Aircraft on ground signal from at least one LGCIU[7], and thrust lever angle reverse signal from the flight control primary computer 1 or 3 (FCPC1 or FCPC3). Due to three FCPC being failed, the thrust reverses could not deploy.

Regarding the ground spoilers not function properly, referred to FCOM DSC-27-10-20, to extend ground spoilers automatically at landing requires: (1) ground spoilers are armed, (2) all thrust levers are at idle, and (3) both main landing gears have touched ground. Reviewing the FDR data, ground spoiler handle was armed before landing (1746:54). Thrust lever retarded to idle position at 1746:51 (3 seconds before touchdown). The occurrence aircraft experienced 2 air-ground transitions (1746:54.0 and 1746:55.5 separately). The PM once called out "spoiler" at landing (1746:55.1). According to FDR data, the ground spoiler start to extend at 1746:55, but ground spoilers retracted and maintained at stowed position after 1746:57. According to AMM 27-93-00-00, ground spoilers can be activated if any FCPC is available. The occurrence aircraft lost 1,2,4,5 ground spoilers since all 3 FCPCs were fault at touchdown.

To clarify the failure sequence of autobrake, thrust reverser and FCPC, a review of FDR data was done. FDR data indicated FCPC1, FCPC2, and FCPC3 faulted at the same time, 1746:58. This is not exactly right timing, because the recording frequency of FCPCs are at 1/4 HZ (1 sample per 4 seconds) which means that all FCPCs were faulted between 1746:54 (all FCPCs were still normal) and 1746:58. By looking the FDR parameter

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[6] FADEC: Full Authority Digital Engine Control
[7] LGCIU: Landing Gear Control Interface Unit

"side stick left roll[8]", a spike was noticed at 1746:56.25 which is could be the time of master control change from FCPC to FCSC. Based on the above information, the FCPCs would be faulted at 1746:56.25 and transferred master control to FCSC. Table 2.2-1 shows sequence of events related to FCPCs, ground spoilers, autobrake, and thrust reversers.

Table 2.2-1 Sequence of key events

Sequences	Time	Events
1	1746:54.0	Main gear touchdown, aircraft in ground mode
2	1746:55.0	Aircraft went to air mode
3	1746:55.5	Aircraft back to ground mode till aircraft fully stop
	1746:56.25	FDR recorded data FCPC1、FCPC2、FCPC3 faulted at 1746:58. After analysis, the more precise time for 3 FCPCs fault is 1746:56.25.
5	1746:57	Ground spoiler disarmed Autobrake fault The FDR data shows flight law changed from "0" to "4" (flight control changed from FCPC1 controlled normal law to FCSC1 controlled direct law).
6	1747[9]	Thrust reversers INOP.

According to the FDR data, FCPC shop test and FCPC control logic,

[8] Sample rate is 4 times a second.

[9] The time of Thrust reverser system failure is reference PFR, time resolution is in minute.

after FCPC1 failed, the flight control system is transferred to FCPC2 and then to FCPC3 in sequence. After the failure of all 3 FCPCs, the flight control is transferred to FCSC, and the flight control is now controlled by FCSC1. The flight control logic will be reconfigured from normal law to direct law. Under the direct law, the flight control surfaces are still controllable, however the following protections of the aircraft were no longer provided: high angle of attack (AOA) protection, load factor protection, pitch attitude protection, bank angle protection and high-speed protection. The flight control surfaces react directly according to the pilot's sidestick and rudder pedal input. Because of the failure of 3 FCPCs, the ground spoiler were cancelled during landing, thrust reverser could not be deployed, and autobrake system could not be activated. The deceleration of the aircraft depends on the pilot's manual braking.

In summary, the loss of autobrake, ground spoiler and thrust reverses during landing roll were due to all 3 FCPCs faulted at touchdown. After all 3 of FCPC faulted, the flight control law was reconfigured from normal law to direct law. The flight control surfaces were still controllable in direct law, however the deceleration systems including ground spoilers, thrust reversers and autobrake could not be activated. The deceleration of the aircraft relied on the pilot’s manual braking.

2.3 FCPC Failure Analysis

To figure out the probable cause of all three FCPC failures, the FCPC1 was sent to the Airbus for testing. The test results are as described in 1.16.2. The bench test showed that FCPC1 was no fault found (NFF). The fault code of occurrence flight shows SAO. Airbus explained the SAO indicates that certain conditions do not conform to the FCPC’s program specifications and trigger the fault code. The FCPC hardware has no fault.

After receiving the information related to FCPC fault and “SAO” from Airbus. Investigation team learnt following information of FCPC and

SAO fault.

Each FCPC has two channels: command channel (COM) and monitor channel (MON). The computer's COM channel sent control signals to the electro hydraulic servo control to move the control surface to the appropriate position (based on orders from the master FCPC). The MON channel also computed the appropriate control surface position and compared the results with the COM. Both channels receive the same input and perform the same calculation independently. Each FCPC channel (COM channel, MON channel) computes the flight control logics cyclically and compare the output between channels. If the differences of calculated output signal of the two channels exceed the tolerances, the FCPC fault will be triggered. The two channels are electrically and mechanically separated by two partitions. There is an independent clock in each channel, the COM and the MON channels are synchronized when they are powered on. Due to the tolerance of the clock, as time increases, there will be a difference with cyclic change between COM channel and MON channel when performing the same task. The time difference is called asynchronism.

Asynchronism exists between COM and MON channels even under normal conditions and generally does not cause problems, but under special circumstances such as air/ground condition transition combined with rudder pedal inversion, the rudder order difference between COM and MON channels could be increased and the calculated difference may exceed the programmed preset limitations (monitoring threshold). Such as the occurrence flight the air/ground state changed from air mode to ground mode twice in a short period of time together with the rudder pedal input (lateral control) being inverted during air/ground transition. At this moment the lateral control is changed from flight law to ground law[10]. The

[10] This law, engaged on ground, this function increases yaw efficiency in case of engine failure on ground. It is inhibited in flight.

asynchronism difference could be increased and exceeding the preset programmed limitation due to control law changing. Airbus confirmed that no other triple PRIM fault at touchdown event had been reported on A330/A340 aircraft family since entry into service. The A330/A340 fleet fitted with electrical rudder has accumulated 8.7millions of Flight Cycles and 44.3 millions of Flight Hours (in-service data from April 2020).

According to the Airbus root cause analysis (see 1.18.2 for details), the reasons for the aircraft experienced the quasi-simultaneous failure of the 3 flight control primary computers (FCPC or PRIM) are:

(1) The asynchronism of the three FCPCs are all at a high point during touchdown;

(2) When the aircraft touchdown, the lateral control law changed from flight law (the rudder order is filtered) to ground law (the rudder order is unfiltered).

(3) Rudder pedal input was pushed and released twice during a short period close to touchdown.

When the rudder order difference between COM and MON exceeds the monitoring threshold, the FCPC1 will be faulted. When FCPC1 faulted, flight control will transfer to FCPC2 and FCPC3 in sequence by design and FCSC finally took over of the flight control. Airbus analysis report confirmed that a single FCPC may fail in a situation similar to the occurrence flight.

According to Airbus analysis report provided on February 12, 2021 (1.18.2), Airbus reviewed its in-service experience, and confirmed that no other triple PRIM fault at touchdown event had been reported on A330/A340 aircraft family since entry into service. The A330/A340 fleet fitted with electrical rudder has accumulated 8.7 millions of Flight Cycles and 44.3 millions of Flight Hours (in-service data from April 2020). After this occurrence, Airbus has issued Operator Information Transmission-OIT No.999.0054/20 (reference Appendix 4) on July 28, 2020 to inform all A330/340 operators of this incident. The Airbus analysis report also states the company's proactive safety actions (FCPC software enhancement schedule), as detailed in 4.2.

2.4 Stable approach and manual landing

During descent, the landing gear was down and locked at barometric altitude 3,376 feet；ground spoilers were last armed at 2,400 ft; flap FULL position was selected at barometric altitude 1,928 feet. Landing configuration was completed before 1,500 feet AAL. Below 1,000 RA of the approach, maximum descent vertical speed was -1,024 ft/min at RA 495 feet, maximum glide slope deviation was 0.71 dot at RA 203 feet, maximum localizer deviation was 0.15 dot at RA 93 feet, approach speed was between 129.5~143kts, actual N1 were more than 40 % for both engines. During approach, the aircraft is in the desired landing configuration; and airspeed, not more than target speed(133kts) +15kt and not less than VREF/ VLS; and Maximum sink rate less than 1,200ft/min; and engines spooled up; and the flight path was less than 1 dot deflection on the localizer and glideslope. The touchdown down point was within the touchdown zone, TDZ. All flight parameters were satisfied by stable approach criteria that are defined in FCOM.

The aircraft's main landing gears touched runway 10 at 1746:54 with a ground speed of 147kts and ground spoilers start to extend. The PM called out” spoilers” right away. At 1746:57, 3 seconds after touchdown, both thrust reversers levers were selected to the IDLE position. At 1746:57, all ground spoiler, thrust reverser, and autobrake system were inoperative. At 1746:59, the PM called” reverse” trying to remind the PF to apply thrust reverser (PM didn’t notice PF already applied thrust reverse). At 1746: 59.2, the PF asked twice “autobrake is on" (ground speed was 141kts), and the PM immediately replied, "autobrake is not on". At 1747:00, thrust reverser levers were set to MAX REV. the PF felt almost no deceleration rate (ground speed 134kts), at 1747:04.6, he called out "manual brake" and stepped on the full brake pedal while the nose landing gear air/ground switch still bouncing between air/ground mode.

On 1747:07 CVR, the PM called ”reverse no green” and next second, the PF called out " quickly help me brake help me brake ". The normal brake pressure was up to 576 psi with full brake pedal from both pilot, longitudinal acceleration was only -0.14g. The PF recalled that "manual brake was used and the deceleration rate was significantly abnormal" in interview. At 1747:24, speed about 70kts, longitudinal acceleration -0.285g, thrust levers were kept in MAX REV position till aircraft fully stopped but reversers function was inoperative. According to pilots actions, the manual landing procedure of FCOM SOP were followed by pilots for flare, touchdown and roll out till aircraft was came to fully stop. During the landing roll, the crew kept good interaction and high situation awareness based on the PF’s response to decelerate the aircraft and the PM's callouts of relevant abnormal system status.

2.5 Factored Landing Distance Margin analysis

To discuss relevant landing distance issues of occurrence flight, the investigation team used the Airbus Flysmart runway performance analysis software. It was based on the same landing weight, without the use of thrust reversers, same landing runway 10 in RCSS as the occurrence flight and changed the different malfunction, autobrake mode, runway condition, and tailwind to check the remaining runway distance. The results are shown in Table 2.5-1.

- Factored Landing distance (7kts tail wind) was 6,183 feet for landing weight 343,000lbs with ground spoiler function normal, no reversers and maximum manual brake, Flap FULL in runway condition GOOD .

- Factored Landing distance (7kts tail wind) was 6,787 feet for landing weight 343,000lbs with ground spoiler function normal, no reversers, MED autobrake, Flap FULL in runway condition GOOD.
- Factored Landing distance (7kts tail wind) was 8,375 feet for landing weight 343,000lbs with PRIM1+PRIM2+PRIM3 Fault (all ground spoiler, autobrake, reversers inoperative) and maximum manual brake, Flap 3 in runway condition GOOD. Factored Landing margin of RCSS runway 10 (LDA 8,547 feet) was 172 feet to runway end.
- Factored Landing distance (10kts tail wind) was beyond runway length for landing weight 343,000lbs with PRIM1+PRIM2+PRIM3 Fault (all ground spoiler, autobrake, reverser inoperative) and maximum manual brake, Flap 3 in runway condition GOOD. Factored Landing margin of RCSS runway 10 (LDA 8,547 feet) was short 379 feet.
- Factored Landing distance (10kts tail wind) was beyond runway length for landing weight 343,000lbs with all ground spoiler inoperative, no reversers and maximum manual brake, Flap FULL in runway condition GOOD. Factored Landing margin of RCSS runway 10 (LDA 8,547 feet) was short 158 feet.

According to table 2.5-1, factored landing distance will increase about 2,000 feet with maximum manual brake, comparing PRIM1+PRIM2+PRIM3 Fault compared to normal landing, in runway braking GOOD condition. Factored landing margin was 172 feet to runway end with a 7kts tailwind. When wind increasing to a maximum of 10kts, Factored landing margin was 379 short feet. When all ground spoiler fault with flap full landing in 10 kts tailwind was calculated, with lower approach speed, Factored Landing margin was short 158 feet.

Table 2.5-1 Factored Landing margin with different scenarios

LDG Wt kLB	System Inop.	Eng Rev.	Brake Mode	RWY Cond	Tail wind kts	Conf.	LDG Dist.	Factored LDG Dist.	F-LD Margin[11]
343	normal	no	manual	good	7	CONF FULL	5,377	6,183	2,364
343	normal	no	MED	good	7	CONF FULL	5,901	6,787	1,760
343	3FCPC	no	manual	good	7	CONF 3	7,283	8,375	172
343	3FCPC	no	manual	good	10	CONF 3	7,762	8,926	-379
343	All Spoiler	no	manual	good	10	CONF FULL	7,569	8,705	-158

From Table 2.5-1, under normal conditions, even without thrust reverser, whether it is automatic or manual braking, the factored runway distance margin exceeds 1,700 feet. However, once all three FCPCs failed and the maximum manual brake applied with tailwind 7 kts, the factored runway distance is only 172 feet. For the occurrence flight, the actual runway distance remaining was 30 feet which was less than the calculated value (172 feet). This could be due to the actual tailwind is stronger, the actual runway surface condition is worse than the calculated preset value, and the maximum manual brake cannot be activated immediately (pilot needs time to respond) after main landing gear touchdown. Under the same circumstances, if the tailwind reaches 10kts, the length of the runway is insufficient.

In summary, the aircraft condition of the occurrence flight was normal before landing, there was no problem with the runway performance analysis used by the pilot, and there was enough runway remaining according to the calculation results. In the occurrence flight of three FCPC failures, the actual remaining runway distance (30 feet margin) was shorter

[11] F-LD Margin was the distance between factored landing distance to the runway end。

than the calculated value (172 feet margin), possibly due to tailwinds, runway conditions and the pilots need response time to realize the situation to apply manual brake, these factors might increase the stopping distance.

2.6 Long landing additional risk

In occurrence flight, because of neither MEL item nor ECAM alert that affects the landing performance was taking account into In-Flight Landing Distance computation. And 3 FCPC were failed at touchdown, pilots having no clue to prepare in advance, maximum manual braking was not possible to be initiated immediately after main gear touchdown as described in SOP.

At 1746:48, the aircraft crossing runway 10 threshold with RA 46 feet. 6 seconds later, at 1746:54, aircraft touch down at about 1,470 feet from the runway threshold. At 1746:55.5, the aircraft second touchdown at about 1,840 feet from the runway threshold. Pilots checked ground spoilers, thrust reversers and autobrake according to procedure. At 1747:02, 6.5 seconds after the second touchdown, both pilot checked and confirmed no autobrake then the manual brake was applied. The maximum brake pedal angle was reached at 1747:04. However, the aircraft was stopped about 30 feet just before the runway end.

In normal conditions, the pilot was seldom to initiate maximum manual braking immediately after the main gear just touchdown or quicker than the occurrence flight. If 3 FCPC failed at touchdown and air distance was increased more 500 feet or 1,000 feet due to long flare landing. With all other landing factors as same as the occurrence flight, even the touchdown is still within the TDZ (the first 3,000 ft or first 1/3 of the runway), the aircraft might have overrun the runway.

Before the risk of 3 FCPCs faults at touchdown not being completely removed, and it is hard to avoid flight crew from making a long landing, the operators should consider setting more conservative dispatch or landing risk control measures for landing at short runways, tailwinds, and not dry runway surfaces. The operators should also ask his pilots to compute the landing performance with careful considerations and reinforce the pilot's situation awareness of the threats caused by long landing to prevent aircraft from overrunning the runway.

2.7 Runway Conditions and Airplane Deceleration Performance

2.7.1 Runway conditions

According to the measurements before and after the occurrence, each one-third friction value of RWY 10/28 complies with the specification. (See Table 1.10.2) The longitudinal slopes, transverse slopes, and longitudinal slope changes of RWY 10/28 also comply with the specifications. (See Table 1.10.1 and Table 1.10.3)

The cumulative precipitation on RWY 10/28 was between 5.2mm and 8.8mm from surface observation, which shows a heavy rain during the occurrence. ATC already informed "light thunderstorm and rain" to the occurrence flight crew according to the CVR transcript.

Summary, the runway surface friction, longitudinal slopes, transverse slopes, and longitudinal slope changes of the Songshan Airport runway comply with the specification. During the occurrence flight, Songshan Airport was under heavy rain, and the accumulated precipitation on runway 10/28 was between 5.2 mm and 8.8 mm.

2.7.2 Airplane Touchdown Points

According to Aeronautical Information Publication of Taipei FIR, landing distance available (LDA) of runway 10 of Songshan airport is 8,541 feet. Its aiming point marking is 1,331 feet from the threshold of runway 10. In accordance with FDR data, the landing gear squat switch status of the main landing gears are used to determine the touchdown points of the occurrence flight. Based on the result of flight path calculation to determine the touchdown points and landing distances.

At local time of 1746:54, first touchdown point of main landing gear, in which landing distance is about 1,470 feet from the threshold of runway 10. 1.5 seconds later, second touchdown point of main landing gear, in which landing distance is about 1,840 feet from the threshold of runway 10. Eight seconds after the first touchdown point of main landing gear, first touchdown point of nose gear, in which the distance is about 3,400 feet from the threshold of runway 10. Eleven seconds after the first touchdown point of main landing gear, the nose gear second touchdown, in which distance is about 4,100 feet from the threshold of runway 10. At this moment, the brake pedal has reached a maximum of 68 degrees.

2.7.3 Deceleration Performance

During the interview, the PF stated that there may be standing water on the runway. In order to determine whether the aircraft performance was significantly degraded by the water on the runway pavement, this section uses FDR data to analyze aircraft deceleration performance. The landing distance and deceleration performance of the occurrence flight are shown in figure 2.7-1. Based on FDR data and figure 2.7-1, the description is as follows:

- When the occurrence flight passed through the threshold of runway 10. Its radio height ranged from 60 feet to 46 feet,
- According to the main gears air/ground state, the occurrence flight took 6 seconds and 7.5 seconds to travel about 1,470 feet and 1,840 feet respectively, with respect to the threshold of runway 10.
- According to nose gear air/ground state, the occurrence flight

took 12.5 seconds and 15.5 seconds to traveled about 3,400 feet and 4,100 ft respectively, with respect to the threshold of runway 10.

- Between the region of 4,300 feet and 6,400 feet of runway 10, the deceleration performance of occurrence flight was “good”.
- Between the region of 6,400 feet and 7,300 feet of runway 10, the deceleration performance of occurrence flight was between “poor” and “medium”.
- Between the region of 7,300 feet and 8,000 feet of runway 10, the deceleration performance of occurrence flight was between “medium to good” and “good”.
- Between the region of 8,000 feet and 8,400 feet of runway 10, the deceleration performance of occurrence flight was “good”.

With the FDR data plot of brake pedal angle, braking pressure and the ground trajectory of the occurrence flight (figure 1.11-5), it was found that the deceleration performance of the occurrence flight between 6,600 feet and 7,300 feet from the threshold of runway 10 deteriorated. It might be due to the runway marking and rubber deposit on the touchdown zone of runway 28.

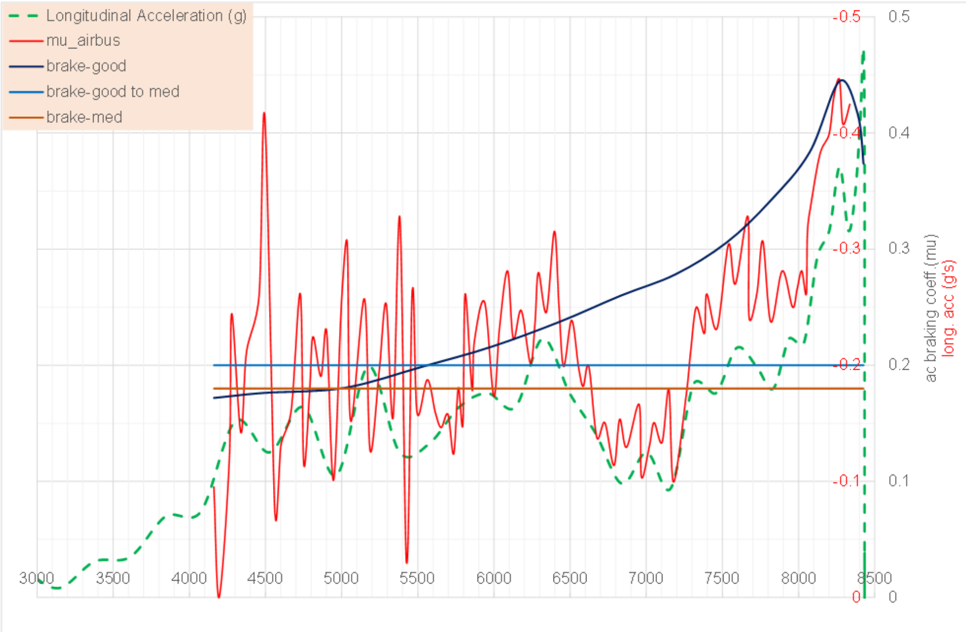


Figure 2.7-1 Landing distance and deceleration performance

The occurrence flight first touchdown and second touchdown were about 1,500 feet and 1,800 feet respectively, with respect to the threshold of runway 10. After the flight crew applied manual braking, the overall deceleration performance ranged between "medium" and "good", which should be able to rule out the impact of effect of hydroplaning during the landing roll operation.

Chapter 3

In this Chapter, findings derived from the factual information gathered during the investigation and the analysis of the occurrence flight are presented. The findings are presented in three categories: **Findings Related to Probable Causes**, **Findings Related to Risk** and **Other Findings**.

Findings Related to Probable Causes

The Findings Related to Probable Causes demonstrates key factors that have operated in the occurrence, or almost certainly operated in the occurrence. These findings are associated with unsafe acts, unsafe conditions, or safety deficiencies associated with the occurrences, etc.

Findings Related to Risk

The Findings Related to Risk demonstrates potential risk factors that compromise aviation safety. These factors include unsafe acts, unsafe conditions, and safety deficiencies that endanger the organization and the system. These factors do not contribute to the occurrence, but increase the probability of the occurrence. Furthermore, some of the findings in this category identify safety deficiencies that are unlikely to be related to the occurrence but, nonetheless, should be pointed out for the sake of aviation safety in the future.

Other Findings

Other Findings identify elements that have the potential to enhance aviation safety, resolve a controversial issue, or clarify an ambiguity point which remains to be resolved. Some of the findings are of general interests that are often included in the ICAO format occurrence report for informational, safety awareness, education and improvement aviation safety purposes.

3.1 Findings related to probable causes

1. The three flight control primary computers (FCPCs) of the occurrence aircraft became inoperative almost at the same time during touchdown. The root cause was determined to be an undue triggering of the rudder order COM/MON monitoring concomitantly in the 3 FCPC. At the time of the aircraft lateral control flight law switching to lateral ground law at touch down, the combination of a high COM/MON channels asynchronism and the pilot pedal inputs resulted in the rudder order difference between the two channels to exceed the monitoring threshold. The FCPC1 failed first. （1.6, 1.11, 1.16.1, 1.16.2, 1.18.2, 2.3）
2. After the FCPC1 failure, the master control of flight control system was handed over to FCPC2 and FCPC3 in sequence whose asynchronism were also high at that moment; thus eventually all three FCPCs became inoperative. As a consequence of the three FCPCs loss, the thrust reversers, the ground spoilers, and the autobrake system were lost, resulting in an increased landing distance for the aircraft. （1.6, 1.11, 1.16.1, 1.16.2, 1.18.2, 2.3）

3.2 Findings related to risk

1. During landing, flight controls reconfigured from normal law to direct law after all three flight control primary computers (FCPCs) became inoperative. While all aircraft primary control surfaces were still controllable, the deceleration devices including ground spoilers, thrust reversers, and autobrake were lost, the deceleration of aircraft was relied on manual brake by the pilots. （1.6, 1.11, 2.2）
2. Given all three flight control primary computers (FCPCs) failed seconds after touchdown, should other factors (long flare, runway state, …) have affected the landing distance, the aircraft could have overrun the runway even if the pilots had immediately applied

maximum manual brake after realizing the autobrake had failed.（1.11, 2.5, 2.6）

3.3 Other findings

1 The occurrence flight crew were properly certificated and qualified in accordance with the requirements of the Civil Aviation Authority of Taiwan. Records of pilots' training and checks have no anomaly related to this occurrence operation. The rest and activities of flight crew 72 hours before the occurrence were normal. No evidence indicated any pre-existing medical conditions or alcohol that might have adversely affected the flight crew's performance during the occurrence flight.(1.5, 2.1）

2 During the approach, flare, landing, and roll out until aircraft came to a full stop, the actions performed by the flight crew complied with stable approach and manual landing Standard Operation Procedures (SOP) prescribed in Flight Crew Operating Manual (FCOM).（1.1, 1.11, 1.17, 2.4）

3 During the landing roll, the crew kept good interaction and high situation awareness based on pilot-flying's response to decelerating the aircraft and pilot-monitor's call out of relevant abnormal system status.（1.1, 1.11, 1.17, 2.4）

4 With three FCPCs inoperative, actual remaining runway distance (30 feet margin) of the occurrence flight was shorter than the calculated value (172 feet margin), possibly due to tailwinds, runway conditions, and manual braking as these factors might increase the braking distance.（1.1, 1.11, 1.17, 2.5）

5 Ground spoiler function requires at least one functional FCPC, arming autobrake requires at least two functional FCPCs, deployment of thrust reversers require unlock signal from either FCPC1 or FCPC3. As a consequence of the three FCPCs loss, the non-release of the independent locking system prevented the reversers' deployment, the

ground spoilers were cancelled and autobrake system was lost.（1.6, 1.11, 2.2）

6 Shop finding of FCPC1 indicated that the unit is no fault found (NFF). The built-in test (BITE) shows SAO（Spécification Assistée par Ordinateur）fault at the time of the triple FCPC fault. The SAO fault corresponds to the fault was trigged during COM/MON monitoring rather than the fault of computer hardware. （1.10, 1.11, 2.7）

7 Following the occurrence, Airbus reviewed its in-service experience, and confirmed that no other triple PRIM fault at touchdown event had been reported on A330/A340 aircraft family since entry into service. The A330/A340 fleet fitted with electrical rudder has accumulated 8.7 millions of Flight Cycles and 44.3 millions of Flight Hours (in-service data from April 2020). （1.18）

8 The runway surface friction, longitudinal slope, transverse slope, and longitudinal slope changes of the Songshan Airport runway 10 complied with relevant standards. （1.10, 1.11, 2.7）

9 The deceleration performance of the occurrence flight between 6,600 feet and 7,300 feet from the threshold of runway 10 deteriorated. It may be due to runway marking and rubber deposit on the touchdown zone of runway 28.（1.10, 1.11, 2.7）

10 The occurrence flight first touchdown and second touchdown were about 1,500 feet and 1,800 feet respectively with respect to the runway threshold. The touchdown points were both located at runway touchdown zone. （1.10, 1.11, 2.7）

11 After the flight crew applied manual braking, the overall deceleration performance was between “medium” and “good” level consistent with the reported wet condition of the runway, which should be able to rule out the effect of hydroplaning. （1.10, 1.11, 2.7）

Chapter 4

4.1 Safety Recommendations

During the investigation, TTSB maintained close communication with all relevant organizations. The aircraft manufacturer, Airbus, provided proactive safety actions (refer to 4.2) to address the lack of robustness discovered during this investigation with regards to the FCPC COM/MON rudder order monitoring.. The Taiwan CAA also released an Aviation Safety Bulletin related to this occurrence on July 13, 2020. The China Airlines released a Flight Operation Information, FOI 2020-034, to his flight crew on July 3, 2020 and updated version (FOI 2021-007) on February 22, 2021. There is no safety recommendation raised at end of this investigation. Section 4.2 shows the summary of these proactive safety actions taken by each organizations.

4.2 Accomplished or On-going Safety Actions

<u>Safety Actions taken by Airbus</u>

1. ***Short term actions – Communications to Operators***

   The objective of these short-term actions was to remind all affected Operators of the importance of the Landing SOP, in particular during the rollout phase, to minimize the consequences of the triple PRIM failure on the aircraft landing distance.

   <u>Operators Information Transmission (OIT)</u>

   The 28th of July 2020, Airbus issued an Operators Information Transmission (OIT) ATA 27 – A330 Primary Flight Control failures at touchdown (reference 999.0054/20 Rev 00) towards all A330/A340 Operators to inform them of the incident.

   The OIT is provided in the Annex 4.

<u>AirbusWIN video</u>

The 28th of December 2020, Airbus published a video on its Worldwide Instructor News website

(AirbusWIN, https://www.airbus-win.com*), which detailed:*

- The deceleration means at landing and the logic behind them

- The standard callouts during landing in normal operations

- The callouts during landing in the event of abnormal operations

The video can be downloaded under the following link: <u>https://www.airbus-win.com/wp-content/uploads/2020/12/what-about-deceleration-means-at-landing-en.mp4</u>

2. FCPC software enhancement addressing the root cause

A software enhancement will be implemented in the next FCPC standards on the A330 family, to address the root cause of the B-18302 event:

- P19 for the A330-200 (Ceo) and A330-800 (Neo), targeted for Q3-2022

- M28ceo for the A330-300 (Ceo), targeted for Q3-2023

- M3x for the A330-900 (Neo), targeted for mid 2024

The modification will consist of several system improvements:

- Decrease of the COM/MON asynchronism level for the flight/ground information treatment

- Improvement of the COM/MON rudder order monitoring robustness in case of ground to flight and flight to ground transitions

- *Higher unitary monitoring robustness during such transitions*
- *Avoid cascading/"domino's" effect that leads to several PRIM fault*

3. ***FCPC specification robustness review***

Following the event, Airbus has launched a detailed review of the FCPC software specification, focusing on the COM/MON monitorings during the flight/ground transition. The objective was to detect potential robustness issues, going beyond the scenario of the B-18302 event. At the time of writing of this report, this review is still on-going.

At this stage, Airbus has not identified another type of COM/MON monitoring robustness issue that could result in an undue monitoring triggering with subsequent repercussions having similar level of severity than the B-18302 event.

<u>Safety Actions taken by CAA, Taiwan</u>

Civil Aeronautics Administration released ASB No：109-060/O R1 on July 13, 2020.

Subject:

An ROC-registered A330 encountered a loss of all three primary flight computers (P1/P2/P3), the thrust reverser system and its automatic braking system upon landing on a wet runway. The root cause is still under investigation. All A330 operators shall set countermeasures for the abovementioned condition to ensure flight safety.

Description:

Upon landing on a wet runway with the thrust reverser system activated, the flight crew on an A330 aircraft noticed the loss of all three primary flight computers (P1/P2/P3), the thrust reverser, spoilers and automatic braking systems, thus affecting aircraft *deceleration. Maximum manual braking was applied, and the aircraft was stopped right before the end of the runway safely. For safety concerns, the flight crew requested aircraft-towing.*

Recommendations:

1. Before any A330 flight dispatch, consider possible deceleration deficiency with the conditions mentioned above if the runway condition is reported "wet" at the destination airport.

2. Corresponding landing distance required on a wet runway shall be predetermined. If the landing distance available is a concern, consider diverting to an alternate airport.

3. Operators shall enhance crew's awareness of wet runway operations for proper aircraft deceleration. If automatic braking is out of function, promptly apply manual braking.

4. ROC-registered Airbus aircraft operators with similar flight control computers and braking systems should refer to this bulletin to ensure flight safety.

Safety Actions taken by China Airlines

1. China Airlines released a Flight Operation Information, FOI 2020-034, to her flight crew on July 3, 2020 and updated version (FOI 2021-007) on February 22, 2021.

SUBJECT: *CONSIDERATION FOR LANDING ON SHORT RUNWAY UNDER WET OR SLIPPERY CONDITION*

MESSAGE :
Recently there was a case regarding A330 landed on TSA airport under heavy rain with deceleration devices malfunction.

Before landing on wet or slippery runways, crew should apply

FlySmart to calculate 2 landing distances during approach preparation:

1. Normal landing distance,
2. Given condition;
  a. RW condition: Good or reported RWY condition / braking action, whichever is worse
  b. BRK mode: Manual
  c. REV: NO
  d. ECAM: F/CTL SPLRS FAULT (ALL SPLRS)

If the calculated factored landing distance (F-L/D DIST) from condition 2 is marginal, PIC should carefully consider select longer runways, using maximum manual brake, reducing weight or diversion.

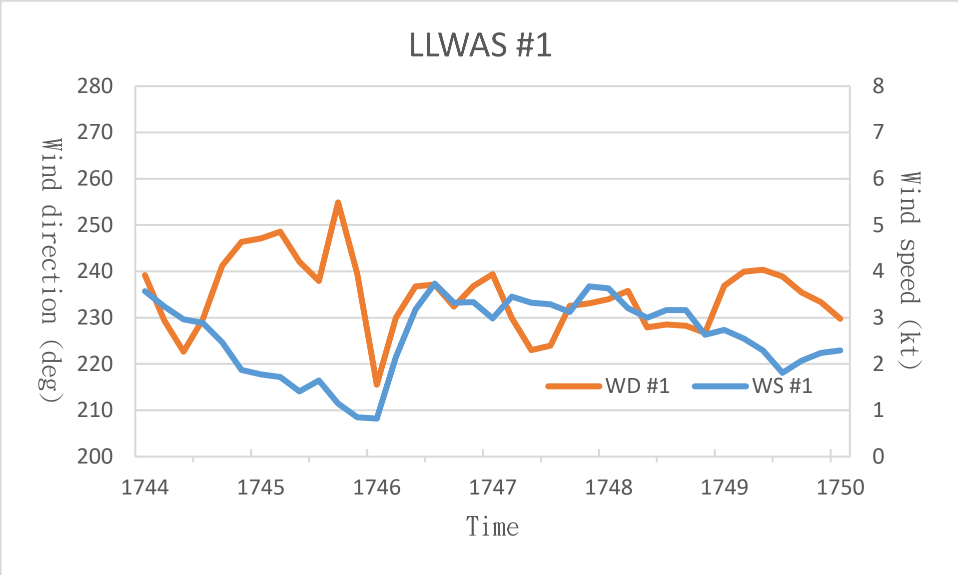
Pay extra attention on short runways (such as TSA, KHH, NRT 16L/34R, HND 22, SYD 07/25…etc.). For flare and landing operation, flight crewmember shall be vigilant and close monitor the aircraft system operation such as autobrake and reversers, and take proper actions immediately when necessary such as application of manual brake.

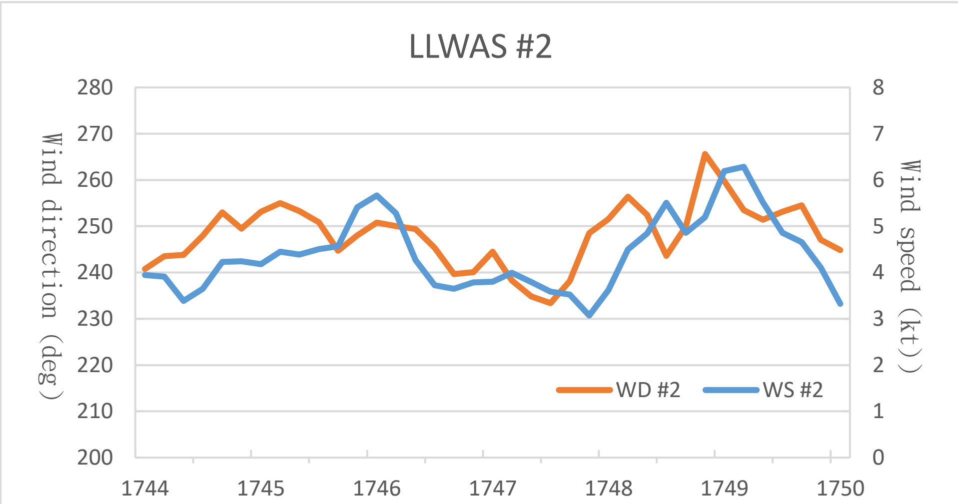
2. *For disseminating potential hazards of the long landing if encountering situation similar to this incident with the condition of short runway, tail wind, and wet runway surface, China Airlines has made the flight safety poster about this case in Q2 2021 and has made it as a lesson learnt in the 1st half EBT briefing to the flight crew to be aware of the long landing risk.*

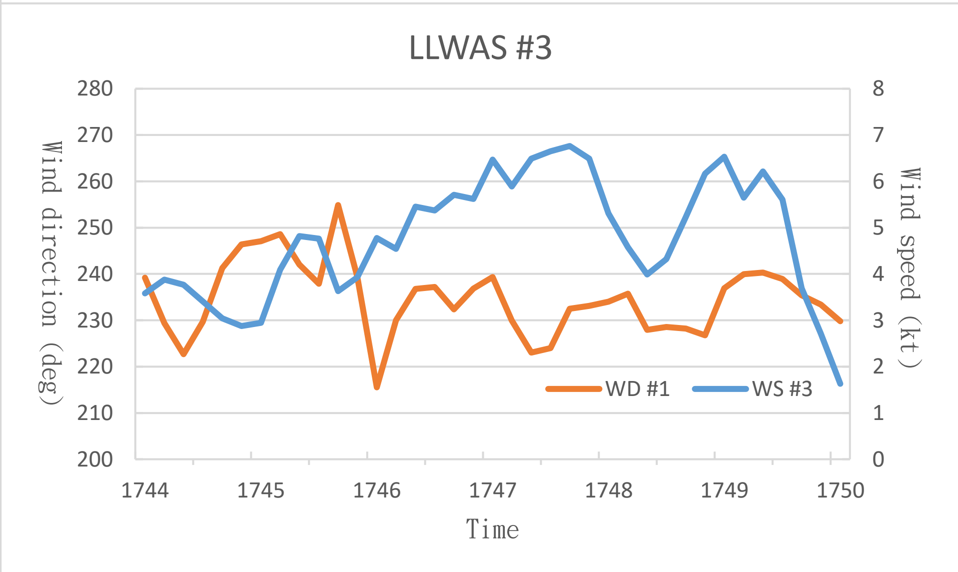
3. *Regarding conservative dispatch, CAL has examined every authorized airports. Risk-controlled measure of this event is as follows:*
   For A330 flights using runway length shorter than 9,000 feet, in addition to ensure aircraft relative deceleration systems are normal for

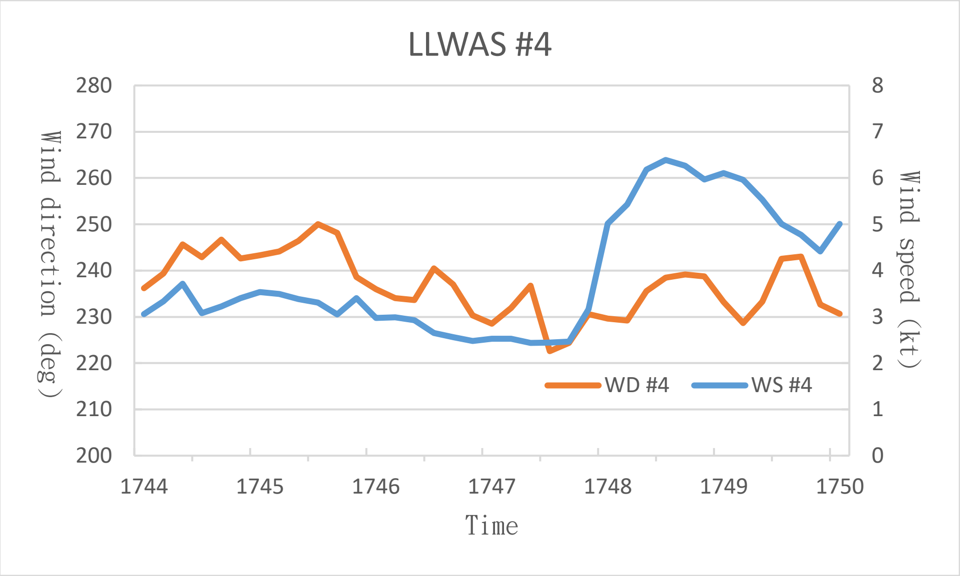
dispatch, when calculating landing performance, the dispatchers will not use ground spoilers nor reversers as benefit for conservative dispatch principles.

Appendix 1: Related anemometer records of the LLWAS





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Wind direction (deg)
Wind speed (kt)
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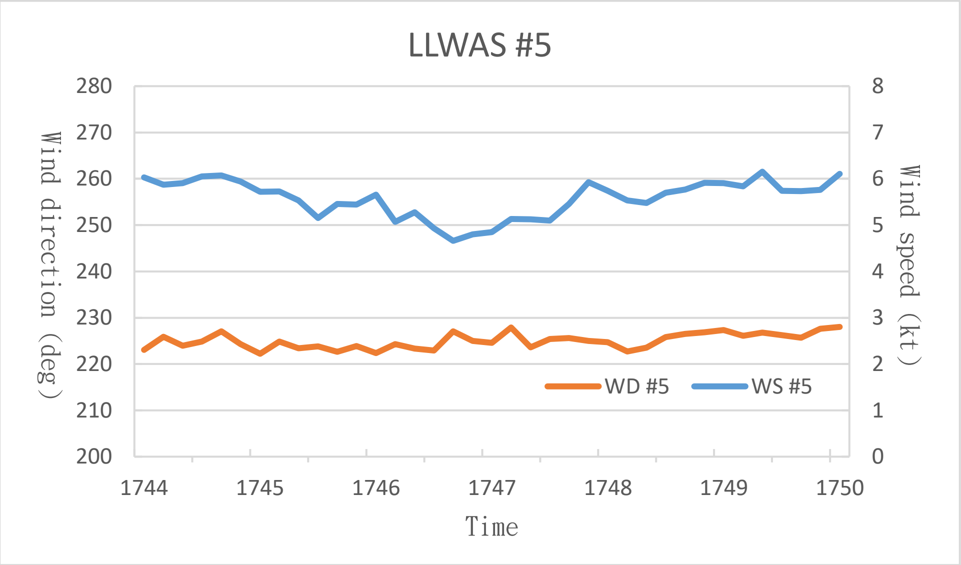
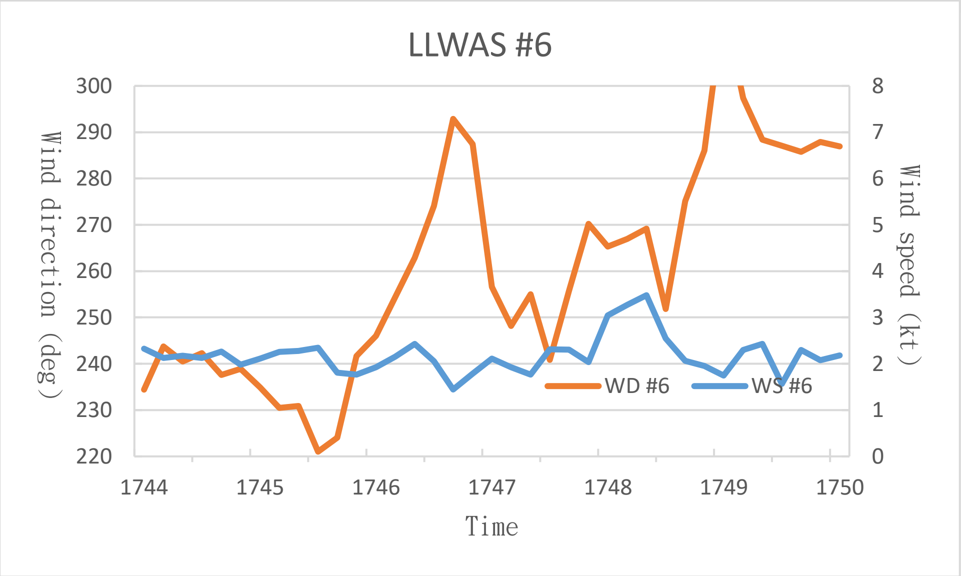
270
260
250
240
230
220
210
200
8
7
6
5
4
3
2
1
0
1744
1745
1746
1747
1748
1749
1750
Time
WD #4
WS #4


LLWAS #5
Wind direction (deg)
Wind speed (kt)
280
270
260
250
240
230
220
210
200
8
7
6
5
4
3
2
1
0
1744
1745
1746
1747
1748
1749
1750
Time
WD #5
WS #5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Wind direction (deg)
Wind speed (kt)
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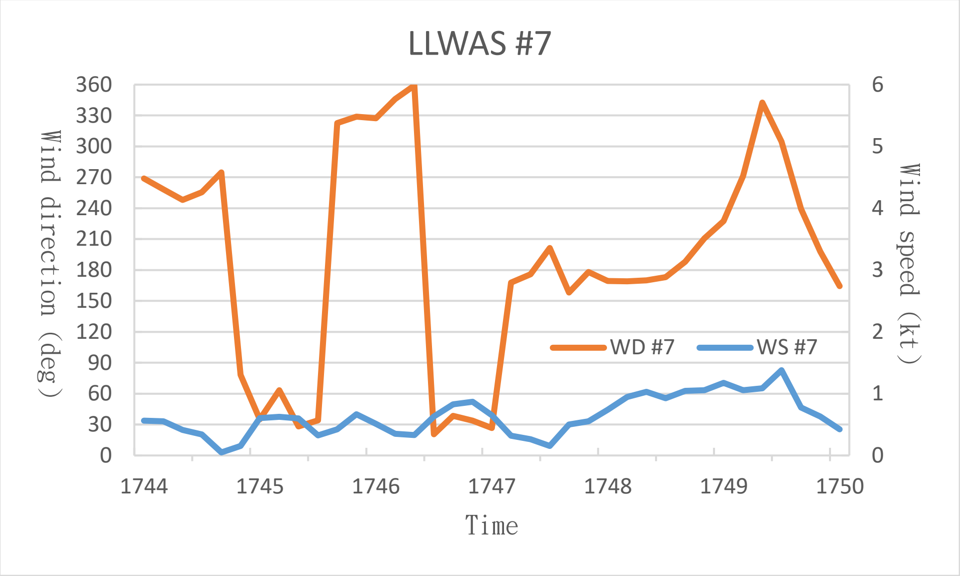
290
280
270
260
250
240
230
220
8
7
6
5
4
3
2
1
0
1744
1745
1746
1747
1748
1749
1750
Time
WD #6
WS #6


LLWAS #7
Wind direction (deg)
Wind speed (kt)
WD #7
WS #7
Time
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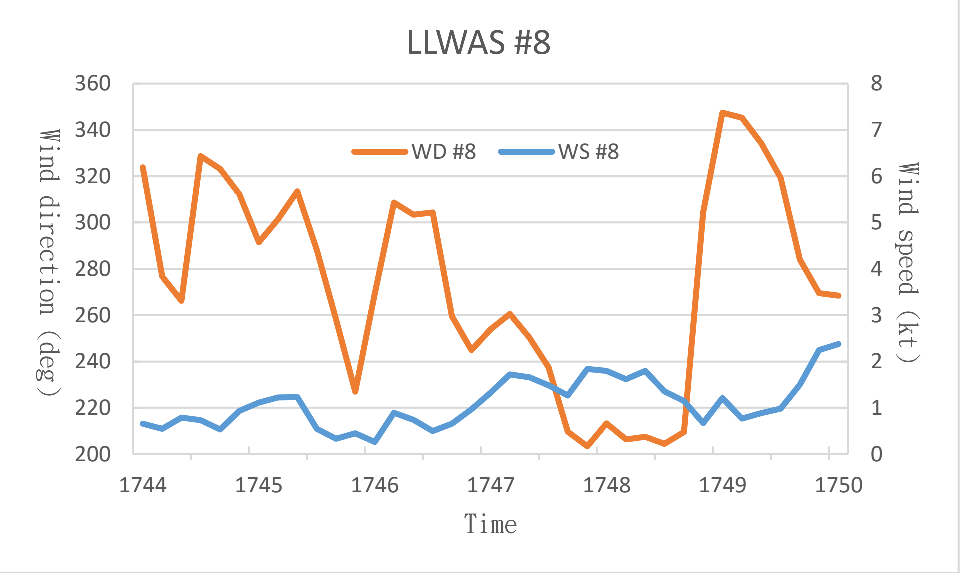
330
300
270
240
210
180
150
120
90
60
30
0
6
5
4
3
2
1
0
1744
1745
1746
1747
1748
1749
1750


LLWAS #8
Wind direction (deg)
Wind speed (kt)
WD #8
WS #8
Time
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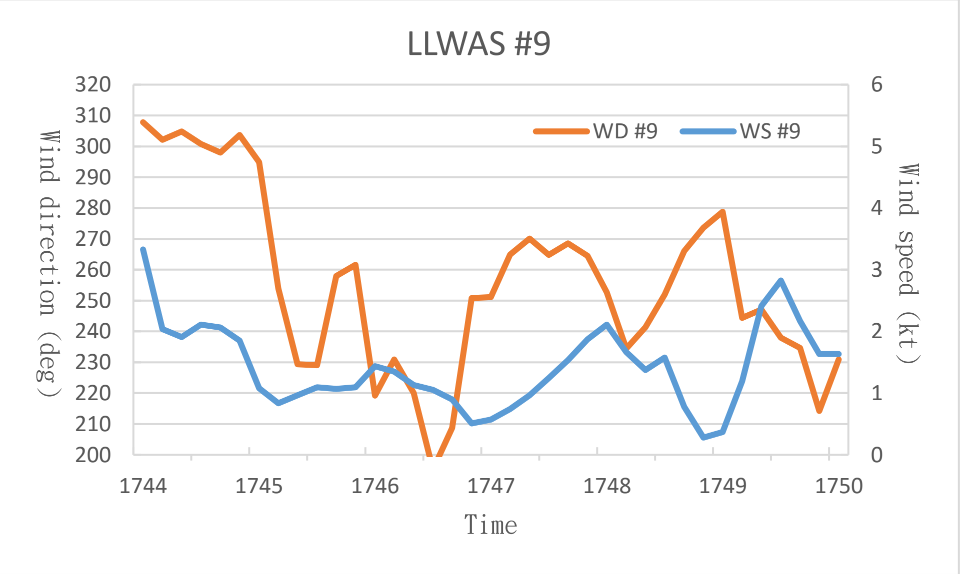
340
320
300
280
260
240
220
200
8
7
6
5
4
3
2
1
0
1744
1745
1746
1747
1748
1749
1750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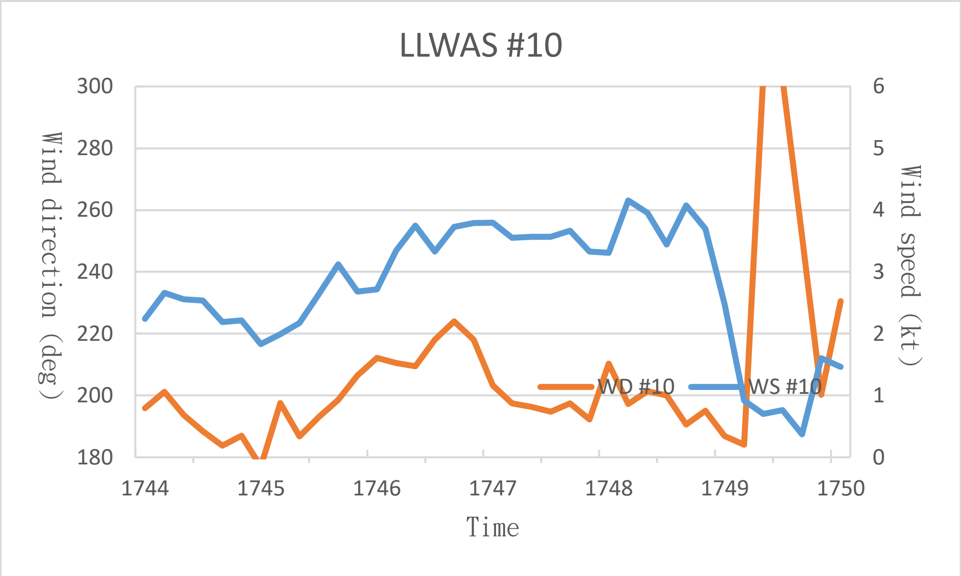
Wind direction (deg)
Wind speed (kt)
WD #9
WS #9
Time
320
310
300
290
280
270
260
250
240
230
220
210
200
6
5
4
3
2
1
0
1744
1745
1746
1747
1748
1749
1750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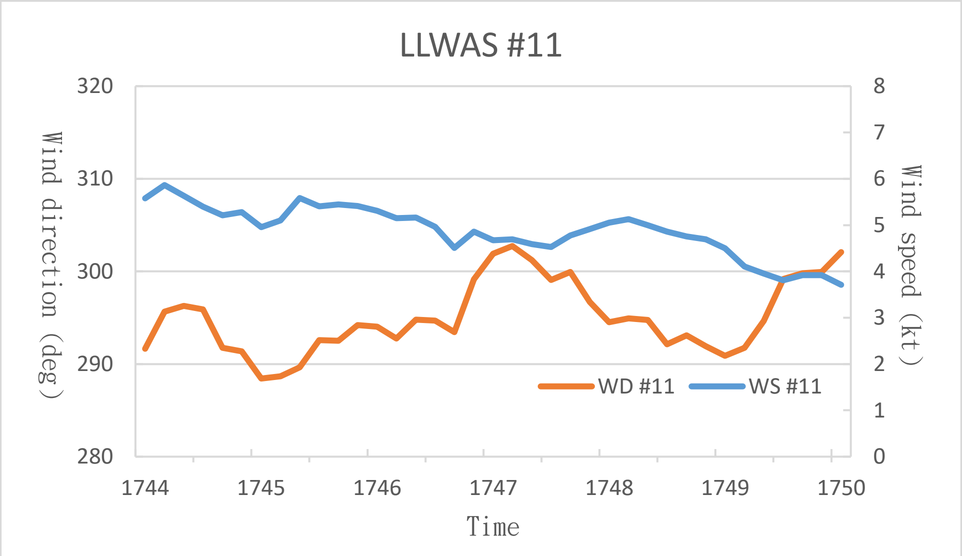
280
260
240
220
200
180
6
5
4
3
2
1
0
Wind direction (deg)
Wind speed (kt)
WD #10
WS #10
1744
1745
1746
1747
1748
1749
1750
Time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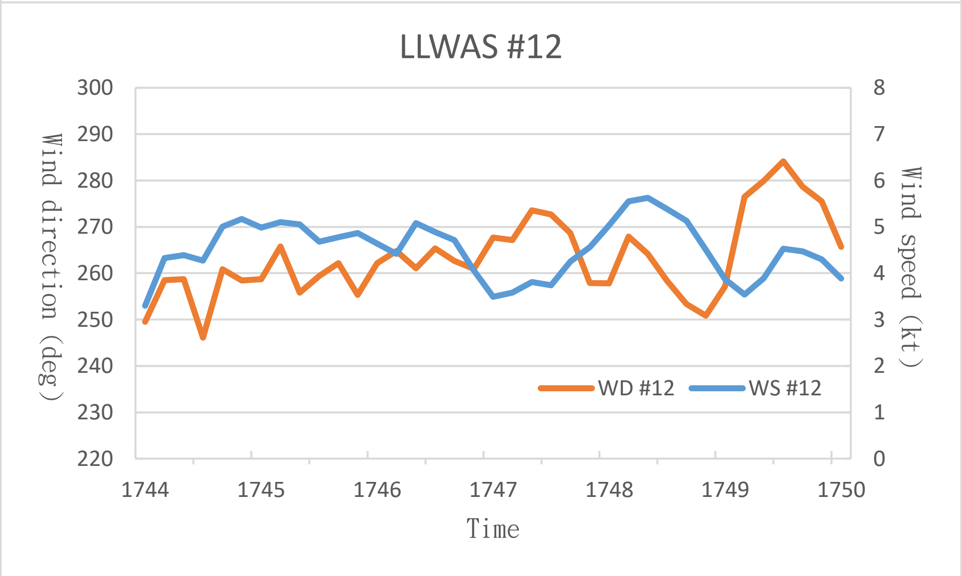
8
7
6
5
4
3
2
1
0
Wind direction (deg)
Wind speed (kt)
WD #11
WS #11
1744
1745
1746
1747
1748
1749
1750
Time


LLWAS #12
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290
280
270
260
250
240
230
220
8
7
6
5
4
3
2
1
0
Wind direction (deg)
Wind speed (kt)
WD #12
WS #12
1744
1745
1746
1747
1748
1749
1750
Time

Appendix 2: The CAA ASB No: 109-060/O R1

交通部民用航空局飛安公告

Aviation Safety Bulletin

ASB No: 109-060/O R1 **July 13, 2020**

Subject:

An ROC-registered A330 encountered a loss of all three primary flight computers (P1/P2/P3), the thrust reverser system and its automatic braking system upon landing on a wet runway. The root cause is still under investigation. All A330 operators shall set countermeasures for the abovementioned condition to ensure flight safety.

Description:

Upon landing on a wet runway with the thrust reverser system activated, the flight crew on an A330 aircraft noticed the loss of all three primary flight computers (P1/P2/P3), the thrust reverser, spoilers and automatic braking systems, thus affecting aircraft deceleration. Maximum manual braking was applied, and the aircraft was stopped right before the end of the runway safely. For safety concerns, the flight crew requested aircraft-towing.

Recommendations:

1. Before any A330 flight dispatch, consider possible deceleration deficiency with the conditions mentioned above if the runway condition is reported “wet” at the destination airport.
2. Corresponding landing distance required on a wet runway shall be predetermined. If the landing distance available is a concern, consider diverting to an alternate airport.
3. Operators shall enhance crew’s awareness of wet runway operations for proper aircraft deceleration. If automatic braking is out of function, promptly apply manual braking.
4. ROC-registered Airbus aircraft operators with similar flight control computers and braking systems should refer to this bulletin to ensure flight safety.

Appendix 3: China Airlines FOI 2021-0007

*FOI2020-0034 has been revised to FOI 2021-0007 as follows：

FOI-2021-0007(330) 2021/02/22-2021/12/31

SUBJECT : CONSIDERATION FOR LANDING ON SHORT RUNWAY UNDER WET OR SLIPPERY CONDITION

UNIT IN CHARGE : TPEOLCI

1 Recently there was a case regarding A330 landed on TSA airport under heavy rain with deceleration devices malfunction.

2 Before landing on wet or slippery short runways, crew should apply FlySmart to calculate 2 landing distances during approach preparation:

1.Normal landing distance,
2.Given condition;
a.RWY condition: Good or reported RWY condition / braking action, whichever is worse
b.BRK mode: Manual
c.REV: NO
d.ECAM: F/CTL SPLRS FAULT (ALL SPLRS)

3 If the calculated factored landing distance (F-L/D DIST) from condition 2 is marginal, PIC should carefully consider select longer runways, using maximum manual brake, reducing weight or diversion.

4 Pay extra attention on short runways (such as TSA, KHH, NRT 16L/34R, HND 22, SYD 07/25… etc.). For flare and landing operation, flight crewmember shall be vigilant and close monitor the aircraft system operation such as autobrake and reversers, and take proper actions immediately when necessary such as application of manual brake.

Appendix 4: AIRBUS Operator Information Transmission-OIT

CUSTOMER SERVICES DIRECTORATE
2 ROND POINT EMILE DEWOITINE
31700 BLAGNAC FRANCE
TELEPHONE + 33 (0)5 61 93 33 33

AIRBUS

OPERATORS INFORMATION TRANSMISSION - OIT

SUBJECT: ATA 27 – A330 Primary Flight Control failures at touchdown

AIRCRAFT TYPE: A330,A340

OUR REF.: 999.0054/20 Rev 00 dated 28-JUL-2020

OIT CATEGORY: **Incident**

NOTICE: This OIT provides recommendations on Maintenance and Engineering issues/information. It is left to each Operator's discretion whether to distribute this OIT, or to distribute the information contained in this OIT, to all of their applicable Maintenance and Engineering organizations for information or application of the recommendation.

1. PURPOSE

The aim of this OIT is to inform operators of the incident which occurred at touchdown on an A330 aircraft on Jun 14th 2020.

2. DESCRIPTION

An A330 aircraft experienced the loss of the three Flight Control Primary Computers (FCPCs) at touchdown. The aircraft reconfigured on the Flight Control Secondary Computers (FCSCs).

As a consequence of the three FCPCs loss, the non-release of the independent locking system prevented the reversers' deployment, ground spoilers did not extend and the autobrake system was lost, resulting in increased landing distance. The normal braking system (i.e. with anti-skid) was available, the crew applied manual braking to stop the aircraft.

Based on in-service information available to Airbus, no similar event has been reported on A330/A340 aircraft family since entry into service.

An ICAO Annex 13 investigation led by the Taiwan Transportation Safety Board (TTSB), with the Bureau d'Enquêtes et d'Analyses (BEA) of France as Accredited Representative, has been opened on this event.

In line with ICAO Annex 13 recommendations, Airbus is providing full technical assistance to the BEA and to the TTSB. Technical support is also provided by representatives of the Operator and the EASA Safety department.

In parallel to the ICAO Annex 13 investigation, Airbus continues to analyse this event through their Risk Assessment of airworthiness occurrence process, which EASA Continued Airworthiness department is monitoring and overseeing. Local airworthiness authorities from Taiwan are also involved.

Airbus has no specific operational or maintenance recommendations to raise at this stage of the investigation.

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3. FOLLOW UP

An update will be provided as soon as further consolidated information is available and Airbus is authorized to release it.

4. CONTACTS

Questions about the technical content of this OIT are to be addressed to Airbus Customer Services through TechRequest on Airbus World, selecting Maintenance & Engineering Domain, Engineering Support Section and ATA 27-93.

Best Regards,

Senior Director Hydraulics, Landing Gear
& Flight Controls Systems - SEEL
CUSTOMER SERVICES

End of Report