

AE964 Occurrence Investigation

Executive Summary

On September 20th, 2014, Mandarin Airlines flight AE 964, a scheduled revenue service passenger flight, an ERJ-190, with aircraft registration number B-16821, took off from Zheng Zhou International Airport, Henan Province, China at 1852 Taipei time for Taichung International Airport. There were 2 flight crew members, 1 on board mechanic, 3 cabin crew members and 73 passengers, total 79 people on board.

The Captain occupied the left seat in the cockpit and was the pilot flying (PF) for the AE 964 flight. The first officer (FO) occupied the right seat and was the pilot monitoring (PM). During initial approach, the flight crew received ATIS G weather information: visibility 9,000 feet, wind direction 330 degrees, wind speed 5 knots, thunderstorm overhead and Taipei Approach granted AE964 landing clearance on runway 36 afterward. At 2113:06 Taipei time, Taipei Approach informed flight crew of thunderstorm overhead at Taichung airport. At 2126:26 Taipei time, the aircraft descended through Final Approach Point and Automated Weather Observation System (AWOS) data showed Runway Visual Range (RVR) was 550 meter. However, the tower local controller did not provide the above information to the flight crew. The flight crew turned windshield wiper to HI position, set the Automatic Braking System to MED, set flaps to 5 (20 degrees) at pressure altitude 1,445 feet, and continued approaching.

The final approach was normal prior to reaching the 50 feet level. At a pressure altitude of 1,147 feet, PM noted “runway insight”, PF instructed PM to continue approach with autopilot engaged. At 2128 Taipei time, Automated Weather Observation System (AWOS) data indicated the weather conditions at Taichung airport were: wind 280 degrees at 9 knots, RVR at 550 meter. At 2128:39.6 Taipei time, the EGPWS altitude callout announced “fifty”; and one second later, PF disengaged the autopilot, and the Digital Voice Data Recorder (DVDR) data showed that radio altitude was 46.2 feet at that time. The aircraft attitude was pitch up 6.3 degrees, right bank 4 degrees and (magnetic) heading 358.4 degrees when the EGPWS altitude callout mode announced 20 feet. There was no further automatic broadcast until the aircraft touching down.

The plane deviated to the right of the runway centerline when passing through 50 feet while the flight crew disengaged the autopilot. Between the time of autopilot disengagement and aircraft touchdown, the aircraft began to veer to the right side of the runway center line with localizer illustrated deviation from 0.073 dots to 0.315 dots. According to the DVDR data, the control column veered to the right during flare and thus the aircraft gradually veered to the right downwind side. Data reviewed indicated that the flight crew crosswind correction was either insufficient or was in the incorrect direction. The airplane touched down temporarily at 1,290 feet from runway 36 threshold before bouncing up and touching down again one second later at 1,620 feet from the runway threshold. The flight crew disengaged auto throttle at the time. The aileron and rudder control surfaces were not in accordance with correct crosswind correction positions when the aircraft was touching down at the right side of the runway center line with a light bounce landing. The aircraft continued veering to the right side of the runway. At 2128:51 Taipei time, the nose gear touched down at 2,120 feet from the runway threshold and the right main gear veered off the runway edge. From 2124:16 when the tower granted the landing clearance to 2130:16 when the flight crew reported to the tower and vacated the runway 36, the RVR at runway 36 dropped from 750 meter to 550 meter and then changed back to 750 feet. During the 6 minutes timeframe, there was no RVR information provided to the flight crew.

At 2128:54, number 1 engine EGT dropped, and was lower than idle speed, PM identified Master Caution as engine one failure. Between 2128:57 and 2128:58, the aircraft right main gear rolled back to the runway center line at 3,230 feet from the runway threshold. Neither reverser was deployed during landing roll.

The flight crew taxied the aircraft back to the ramp with single engine, and informed ATC to check whether the aircraft had damaged the runway edge lights. Ground personnel found there were one runway edge light and one runway signage which were damaged. Airline maintenance ground check found that number 2 engine cowling and right main wheel tire were damaged. No personnel were injured.

The Aviation Safety Council (ASC) is an independent agency responsible for civil aviation, public aircraft and ultra-light vehicle occurrence investigations. According to the Republic of China Aviation Occurrence Investigation Act and referencing to the related content of Annex 13 to the

Convention of International Civil Aviation Organization (ICAO), ASC launched an occurrence investigation by law. The organization or agency invited to join the investigation team included: Civil Aeronautics Administration of Ministry of Transportation and Communications, Air Force Command Headquarters, Ministry of National Defense, R.O.C., Mandarin Airlines, (AERONAUTICAL ACCIDENT INVESTIGATION AND PREVENTION CENTER, CENIPA) and Embraer S.A. (ERJ aerospace company). National Transportation Safety Board of the United States of America and Engine manufacturer, the GE Company.

In accordance with procedure, the draft investigation report was revised by the ASC Board members on June 30, 2015, in the 34th Board meeting. The draft report was then distributed to related organizations and agencies for comments. The occurrence investigation report was reviewed and approved by the ASC 37 Board meeting on October 13th, 2015.

Based on the factual information gathered during the investigation and the results of analysis, 25 findings and 17 flight safety recommendations as stated below.

Findings related to probable causes:

1. Under the circumstance of heavy rain, low visibility, no runway center line light and standing water along runway edges, the flight crew might be unable to identify runway visual cues and cross reference the aircraft normal approach profile with the runway. The flight crew should have initiated a go-around.
2. The flight crew did not disengage the autopilot until radio altitude 50 feet. The late autopilot disengagement was not in favor of cross wind maneuver while the aircraft was flaring to the right downwind side.
3. The flight crew used improper cross wind correction during flare to the right downwind side, the aircraft landed on the right side of the runway center line, and continued to drift to the downwind side of the runway.
4. While the aircraft landed at the right side of the runway with light bouncing, the aileron and rudder were not in the correct positions in accordance with cross wind correction. The aircraft continued veering to the right and off the runway after 2 seconds.

Findings related to risks

1. The flight crew neither discussed weather change, nor the correspondent procedures during approach briefing or final approach checklist, did not request tower for further weather information. The flight crew was in lack of situation awareness especially to weather change.
2. If the flight crew was not able to identify the runway center line within initial 3000 ft. runway touchdown zone, the flight crew should have initiated a go-around prior to or during touchdown.
3. The company Flight Operation Manual operating policy regarding flight crew encountering adverse factors during approach was that they may use the autopilot until the minimum usage height, which was different from the recommended Embraer SOPM procedure of autopilot disengagement at MDA/DA/DH.
4. The average transverse slope of Runway 36 is about 0.5% lower than the regulation requirement (1.0-1.5 %). Therefore the poor drainage performance of runway pavement may lead to runway standing water and increased hydroplaning possibility.
5. The occurrence aircraft ran over a manhole. The iron cover of the manhole was not firmly attached, and hence was lifted off by the aircraft. There were a total of 118 similar manholes aside the runway at Taichung Airport.
6. The tower did not advise the RVR values to AE 964 flight crew after the aircraft was transferred from Taipei Approach.
7. The tower did not relay “runway condition wet” to AE 964 flight crew after receiving information from the Flight Operation Office.
8. The copy record of meteorological reports of tower showed the SPECIs of 2045, 2105 and 2116 were not copied.(1.18.2.5, 2.3.1)
9. The meteorological report disseminating procedure adopted by CAA meteorological unit was to send reports to towers via automation system and compile ATIS automatically. However, the Air Force disseminating procedure was to furnish reports to towers by phone, and then the towers would copy the reports and record ATIS manually. The procedure is not only time-consuming but increasing the workload. Errors may occur during the process.

Other findings

1. Flight crew qualifications complied with current civil aviation regulations. No evidence shows that the flight crew had any influences from drugs during the flight.

2. The AWOS per minute wind records maintained by Air Force were unable to provide detailed wind component information when there were runway excursion events.
3. No evidence showed the aircraft encountered hydroplaning during landing operation.
4. The fragile material within the runway area and the grid test result was in compliance with the regulations.
5. The runway 36 width at Taichung International Airport is 60 meters. The existing runway edge lights were only suitable for a runway width of 45 meters, and was not in compliance with the requirements of “Civil Aerodrome Design and Operation Guidance” and ICAO Annex 14.
6. Runway center line lights should be provided on a precision approach runway category I, particularly when the runway is used by aircraft with high landing speeds or where the width between the runway edge lights is greater than 50 meters, which is true for Taichung International Airport runway 36. According to the recommendations from “Civil Aerodrome Design and Operation Guidance” and ICAO Annex 14, the installation of runway center line lights may enhance pilots visual reference during landing operation.
7. No abnormal log entries were found after reviewing maintenance records for the last 6 months, including all scheduled check items after engine one installation and the last scheduled check.
8. System function test, brake system function test, and reverser function test results were normal. Landing gear tire depth treads, brake lining and tire pressure were within the tolerance.
9. Engine on wings test of the ESM 72-00-00-810-324 Engine flameout , and ESM 72-00-00-810-321 Compressor stall results were normal.
10. According to GE engine investigation report, number 1 engine (including FADEC) function was normal and could have been returned to service. Mandarin sent number 1 engine to IHI engine overhaul shop at Japan for test and result was normal.
11. Based on the DVDR data, GE reviewed the probable causes of number 1 engine flame out. The engine investigation report concluded: most probable cause for the left hand engine (LHE) flame-out was water ingestion from the aircraft nose gear when the aircraft had a -20 deg heading.
12. There was an incorrect aileron parameter definition in the DVDR readout document. The positive should be surface down. The incorrect information

was fixed in Embraer's latest DVDR document revision.

Recommendations

To Mandarin Airlines

1. Enhance flight crew on go around (reject landing) training and incorporate sudden loss of visual cues scenario into the training syllabus.
2. Enhance flight crew on weather change situation awareness and weather information monitoring.
3. Review the policies and current operations of automation usage during approach and their compliance with manufacturer guidance. Provide flight crew with detailed automation operation guidance.

To Civil Aeronautics Administration of Ministry of Transportation and Communications

1. Supervise Mandarin Airlines to enhance flight crew on go around (reject landing) training and incorporate sudden loss of visual cues scenario into the training syllabus.
2. Supervise Mandarin Airlines to enhance flight crew on weather change situation awareness and weather information monitoring.
3. Supervise Mandarin Airlines to review the policies and current operations of automation usage during approach and their compliance with manufacturer guidance.
4. Cooperate with Air Force Command Headquarters, Ministry of National Defense, to inspect and improve the drainage performance of Taichung Airport runway pavement.
5. Cooperate with Air Force Command Headquarters, Ministry of National Defense to inspect the manhole design aside the runway of all common used airports, and mitigate the risk of lifted manhole covers when aircraft running over.
6. Cooperation with Air Force Command Headquarters, Ministry of National Defense, to inspect and improve the runway edge lights at Taichung Airport Runway 36.
7. Cooperation with Air Force Command Headquarters, Ministry of National Defense, to evaluate the feasibility to install runway center line lights at

Taichung International Airport.

To Air Force Command Headquarters, Ministry of National Defense

1. Supervise the Communications, ATC and Information Wing to implement ATMP regulations regarding tower advising weather and runway conditions to flight crew.
2. Refer to CAA operation, set up the automation system for meteorological report dissemination and ATIS recording.
3. Refer to CAA operation; provide second by second AWOS wind records.
4. Cooperate with CAA to inspect and improve the drainage performance of Taichung Airport runway pavement.
5. Cooperate with CAA to inspect the manhole design aside the runway of all common used airports and mitigate the risk of lifted manhole covers when aircraft running over.
6. Cooperate with CAA to inspect and improve the runway edge lights at Taichung International Airport.
7. Cooperate with CAA to evaluate the feasibility to install runway center line lights at Taichung International Airport.

Safety Actions already taken

Mandarin Airlines

- Enhance flight crew on go around (reject landing) training and incorporate sudden loss of visual cues scenario into the training syllabus.
 1. “REJECTED LANDING (LESS THAN 50FT)” syllabus will be added into the annual simulator training and checking.
- Enhance flight crew on weather change situation awareness and weather information monitoring.
 1. Flight Operation Division issued Operation Bulletin regarding AE964 occurrence information and corrective measures on September 21, 2014.
 2. Completed annual recurrent training of engine failure on wet and contaminated runway. Additional routine and annual checks will be added to those flight crew been rated last 10% during route checks.

3. Several briefings were given after the occurrence including: conduct Safety of Runway Operations, Judgment and Decision Making training course to IP and CP by China Airlines. Presentations on thunderstorm characteristics, development and overhead thunderstorm, presentations regarding preventing runway excursion and landing on slippery runways will be conducted at technical and safety meetings every June to August annually. Invited the Aviation Safety Council technical personnel to give special briefing on hydroplaning and runway excursion.

Air Force Command Headquarters, Ministry of National Defense

- Supervise the Communications, ATC and Information Wing to implement ATMP regulations regarding tower advising weather and runway conditions to flight crew.
 1. All units required to follow ATMP 2-8-2 regulations regarding tower to provide approach and departure runway visibility, 3-10-2 provide update weather and visibility update information and 3-3-1 landing zone runway conditions. The above requirements will be announced regularly.
 2. Related guidance been made and announced on July 16th and review during the standardization audit.
 3. Air Force will use the occurrence as case study during the annual training and promotion material to the related personnel.
- Refer to CAA operation, set up the automation system for meteorological report dissemination and ATIS recording.
 1. CAA had invited the Air Force Command Headquarter to attend an ATIS installation at Taichung airport joint meeting on May 13th, 2015. CAA ATC related departments will responsible for the equipment purchase and installation. The Air Force Command Headquarter personnel will attend the training courses accordingly in the future.
- Refer to CAA operation; provide second by second AWOS wind records.
 1. Air Force had completed all five Civil Joint Military Airports

with second by second AWOS wind records function and test normal on May 27th, 2015.

- Cooperate with CAA to inspect and improve the drainage performance of Taichung Airport runway pavement.
 1. Air Force will incorporate the working project when conducting the Taichung Airport runway reconstruction plan.
- Cooperate with CAA to inspect the manhole design aside the runway of all common used airports and mitigate the risk of lifted manhole covers when aircraft running over.
 1. Air Force will incorporate the manhole design aside the runway into the 2016 airport construction and maintenance working project.
- Cooperate with CAA to inspect and improve the runway edge lights at Taichung International Airport.
 1. Air Force will submit the Taichung International Airport runway edge lights improvement plan to CAA on 2016 for approval.
- Cooperate with CAA to evaluate the feasibility to install runway center line lights at Taichung International Airport.
 1. Air Force will incorporate the installation of runway center line lights into future project.