TransAsia Airways Flight GE235, ATR72-212A

Loss of Control and Crashed into Keelung River

Three Nautical Miles East of Songshan Airport

Executive Summary

On February 4, 2015, about 1054 Taipei Local Time, TransAsia Airways (TNA) flight GE 235, an ATR-GIE Avions de Transport Régional ATR72-212A (ATR72-600) aircraft, registered B-22816, experienced a loss of control during initial climb and impacted Keelung River, three nautical miles east from its departing runway 10 of Taipei's Songshan Airport. Forty-three occupants were fatally injured, including three flight crew, one cabin crew, and 39 passengers. The remaining 13 passengers and one cabin crew sustained serious injuries. One passenger received minor injuries. The aircraft was destroyed by impact forces. The aircraft's left wing tip collided with a taxi on an overpass before the aircraft entered the river. The taxi driver sustained serious injuries and the only taxi passenger sustained minor injuries. Flight 235 was on an instrument flight rules (IFR) regular public transport service from Songshan to Kinmen.

The accident was the result of many contributing factors which culminated in a stall-induced loss of control. During the initial climb after takeoff, an intermittent discontinuity in engine number 2's auto feather unit (AFU) may have caused the automatic take off power control system (ATPCS) sequence which resulted in the uncommanded autofeather of engine number 2 propellers. Following the uncommanded autofeather of engine number 2 propellers, the flight crew did not perform the documented abnormal and emergency procedures to identify the failure and implement the required corrective actions. This led the pilot flying (PF) to retard power of the operative engine number 1 and shut down it ultimately. The loss of thrust during the initial climb and inappropriate flight control inputs by the PF generated a series of stall warnings, including activation of the stick shaker and pusher. After the engine number 1 was shut down, the loss of power from both engines was not detected and corrected by the crew in time to restart engine number 1. The crew did not respond to the stall warnings in a timely and effective manner. The aircraft stalled and continued descent during the attempted engine restart. The remaining altitude and time to impact were not enough to successfully restart the engine and recover the aircraft.

Had the crew prioritized their actions to stabilize the aircraft flight path, correctly identify the propulsion system malfunction which was the engine

number 2 loss of thrust and then take actions in accordance with procedure of engine number 2 flame out at take off, the occurrence could have been prevented. The investigation report identified a range of contributing and other safety factors relating to the engine's auto feather unit, crew of the aircraft, TransAsia's flight operations and management processes, and the regulatory oversight of TransAsia by the Civil Aeronautics Administration (CAA).

This investigation identified important learning opportunities for pilots, operators, regulatory agencies and aircraft manufacturer to improve future aviation safety and to seek to ensure such an accident never happens again. The Aviation Safety Council (ASC) has issued a series of safety recommendations to TransAsia Airways, CAA and aircraft/engine/component manufacturers to correct the serious safety deficiencies identified during the investigation. The manufacturers of aircraft, engine and auto feather unit have also implemented various safety actions in response to the occurrence.

According to Article 6 of the Republic of China (ROC) Aviation Occurrence Investigation Act, and the content of Annex 13 to the Convention on International Civil Aviation, the ASC, an independent aviation occurrence investigation agency, was responsible for conducting the investigation. The investigation team also included members from BEA (Bureau d'Enquêtes et d'Analyses, France), TSB (Transportation Safety Board, Canada), NTSB (National Transportation Safety Board, USA), ATR (Avions de Transport Régional), P&WC (Pratt & Whitney Canada), UTAS (United Technologies Aerospace Systems)/USA, CAA Taiwan, and TNA.

The 'Draft Final Report' of the occurrence investigation was completed in January 2016. In accordance with the procedures, it was reviewed at ASC's 41th Council Meeting on January 26th, 2016 and then sent to relevant organizations and authorities for comments. After comments were collected and integrated, the English version Final Report was reviewed and approved by ASC's 44th Council Meeting on 26 April 2016. The Chinese version Final Report was reviewed and approved by ASC's 45th Council Meeting on 31 May 2016. Both versions of Final Report were published on 30 June 2016.

There are a total of 25 findings from the draft Final Report, and 16 safety recommendations issued to the related organizations.

Findings as the result of this investigation

The ASC presents the findings derived from the factual information gathered during the investigation and the analysis of the occurrence. The

findings are presented in three categories: **findings related to probable causes**, **findings related to risk**, and **other findings**.

The **findings related to probable causes** identify elements that have been shown to 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 safety significant events that played a major role in the circumstances leading to the occurrence.

The **findings related to risk** identify elements of risk that have the potential to degrade aviation safety. Some of the findings in this category identify unsafe acts, unsafe conditions, and safety deficiencies including organizational and systemic risks, that made this occurrence more likely; however, they cannot be clearly shown to have operated in the occurrence alone. Furthermore, some of the findings in this category identify risks that are unlikely to be related to the occurrence but, nonetheless, were safety deficiencies that may warrant future safety actions.

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 these findings are of general interests that are often included in the ICAO format accident reports for informational, safety awareness, education, and improvement purposes.

Findings Related to Probable Causes

Powerplant

1. An intermittent signal discontinuity between the auto feather unit (AFU) number 2 and the torque sensor may have caused the automatic take off power control system (ATPCS):
   - Not being armed steadily during takeoff roll;
   - Being activated during initial climb which resulted in a complete ATPCS sequence including the engine number 2 autofeathering.
2. The available evidence indicated the intermittent discontinuity between torque sensor and auto feather unit (AFU) number 2 was probably caused by the compromised soldering joints inside the AFU number 2.

Flight Operations

3. The flight crew did not reject the take off when the automatic take off power control system ARM pushbutton did not light during the initial stages of the takeoff roll.

4. TransAsia Airways did not have a clear documented company policy with associated instructions, procedures, and notices to crew for ATR72-600 operations communicating the requirement to reject the take off if the automatic take off power control system did not arm.
5. Following the uncommanded autofeather of engine number 2, the flight crew failed to perform the documented failure identification procedure before executing any actions. That resulted in pilot flying's confusion regarding the identification and nature of the actual propulsion system malfunction and he reduced power on the operative engine number 1.
6. The flight crew's non-compliance with TransAsia Airways ATR72-600 standard operating procedures - Abnormal and Emergency Procedures for an engine flame out at take off resulted in the pilot flying reducing power on and then shutting down the wrong engine.
7. The loss of engine power during the initial climb and inappropriate flight control inputs by the pilot flying generated a series of stall warnings, including activation of the stick pusher. The crew did not respond to the stall warnings in a timely and effective manner.
8. The loss of power from both engines was not detected and corrected by the crew in time to restart an engine. The aircraft stalled during the attempted restart at an altitude from which the aircraft could not recover from loss of control.
9. Flight crew coordination, communication, and threat and error management (TEM) were less than effective, and compromised the safety of the flight. Both operating crew members failed to obtain relevant data from each other regarding the status of both engines at different points in the occurrence sequence. The pilot flying did not appropriately respond to or integrate input from the pilot monitoring.

Findings Related to Risk

Powerplant

1. The engine manufacturer attempted to control intermittent continuity failures of the auto feather unit (AFU) by introducing a recommended inspection service bulletin at 12,000 flight hours to address aging issues. The two AFU failures at 1,624 flight hours and 1,206 flight hours show that causes of intermittent continuity failures of the AFU were not only related to aging but also to other previously undiscovered issues and that the inspection service bulletin implemented by the engine manufacturer to

address this issue before the occurrence was not sufficiently effective. The engine manufacturer has issued a modification addressing the specific finding of this investigation. This new modification is currently implemented in all new production engines, and another service bulletin is available for retrofit.

Flight Operations

2. Pilot flying's decision to disconnect the autopilot shortly after the first master warning increased the pilot flying's subsequent workload and reduced his capacity to assess and cope with the emergency situation.

3. The omission of the required pre-take off briefing meant that the crew were not as mentally prepared as they could have been for the propulsion system malfunction they encountered after takeoff.

Airline Safety Management

4. TransAsia Airways (TNA) did not follow its own procedures when selecting and training pilot flying for upgrade. The TNA's quality assurance processes had not detected that the command selection upgrade process had been compromised.

5. TransAsia Airways (TNA) did not use widely available crew resource management (CRM) guidelines to develop, implement, reinforce, and assess the effectiveness of their flight crew CRM training program.

6. While the TransAsia Airways (TNA) ATR72-600 differences training program was consistent with the European Aviation Safety Agency ATR72 operational evaluation board report and compliant from a Civil Aeronautics Administration regulatory perspective, it may not have been sufficient to ensure that TNA flight crews were competent to operate the ATR72-600 under all normal procedures and a set of abnormal conditions.

7. The ATR72-600 differences training records for the GE 235 flight crew showed that Captain A probably needed more training on the single engine flame out at take off procedure. That meant if the differences training records were stored, adequately maintained and evaluated by appropriate TransAsia Airways (TNA) flight operations and/or quality assurance personnel, the TNA would have had yet another opportunity to review Captain A's ability to handle engine out emergencies.

8. Captain A's performance during the occurrence was consistent with his performance weaknesses noted during his training, including his continued

difficulties in handling emergency and/or abnormal situations, including engine flame out at take off and single engine operations. However, TransAsia Airways did not effectively address the evident and imminent flight safety risk that Captain A presented.

Regulatory Oversight

9. The Civil Aeronautics Administration's (CAA) oversight of flight crew training, including crew resource management (CRM) training, is in need of improvement.

10. The systemic TransAsia Airways (TNA) flight crew non-compliances with standard operating procedures identified in previous investigations, including GE 222, remained unaddressed at the time of the GE235 occurrence. Although the Civil Aeronautics Administration (CAA) had conducted a special audit after the GE 222 accident which identified the standard operating procedures compliance issue, the CAA did not ensured that TNA responded to previously identified systemic safety issues in a timely manner to minimize the potential risk.

Other Findings

1. The flight crew were certificated and qualified in accordance with Civil Aeronautics Administration (CAA) regulations and company requirements. There was no evidence to indicate that the flight crew's performance might have been adversely affected by pre-existing medical conditions, fatigue, medication, other drugs or alcohol during the occurrence flight.

2. Visual meteorological conditions (VMC) prevailed at the time of the aircraft's departure. No adverse weather conditions were present for the flight.

3. The aircraft's certificate of airworthiness and registration were current at the time of the occurrence. The occurrence aircraft was dispatched at Songshan Airport with no known defects and was in compliance with all applicable airworthiness directives and service bulletins. A review of the aircraft's maintenance records before the occurrence flight revealed that there were no defects reported that related to engine number 2 automatic feathering system.

4. Flight crew transferred from conventional flight instruments to a more advanced avionic suite with primary flight display, the visual pattern and information picked up by the crew in an emergency situation may not be retrieved at the same location with the same display.

5. Although the influence of the flight director indication was not demonstrated in the occurrence flight and the logics of ATR flight director bars are consistent with other aircraft types within the industry, the simulator flight illustrated the flight director bars indication during stall warning were in contradiction with the automatic stall protection inputs and thus may disturb the crew.
6. The ATR72 formal document has no general statement of rejecting take off policy and procedure of rejecting take off with both engines operative.

Safety Recommendations

To TransAsia Airways

1. Document a clear company policy with associated instructions, procedures, training, and notices to crew members for ATR72-600 operations communicating the requirement to reject a takeoff in the event that the automatic take off power control system (ATPCS) is not armed as required. (ASC-ASR-16-06-001)
2. Conduct a thorough review of the airline's flight crew training programs, including recurrent training, crew resource management (CRM) training, upgrade training, differences training, and devise systematic measures to ensure that
   - Standardized flight crew check and training are conducted;
   - All flight crews comply with standard operating procedures;
   - All flight crews are proficient in handling abnormal and emergency procedures, including engine flame out at takeoff;
   - The airlines use widely available guidelines to develop, implement, reinforce, and assess the effectiveness of their flight crew resource management (CRM) training program, particularly the practical application of those skills in handling emergencies;
   - Command upgrade process and training comply with the airline's procedures and that competent candidates are selected;
   - ATR72-600 differences training and subsequent line training are sufficient to ensure that flight crews are competent to operate the ATR72-600 under all normal and abnormal conditions; and
   - All flight crew training records during the employment period are retained in compliance with the aircraft flight operation regulations.

(ASC-ASR-16-06-002)

3. Improve the airline's internal quality assurance oversight and audit processes to ensure that recurring safety, training, and administrative problems are identified and rectified in a timely manner. (ASC-ASR-16-06-003)
4. Implement and document an effective and formal pilot performance review program to identify and manage pilots whose performance is marginal. (ASC-ASR-16-06-004)
5. Evaluate the safety culture of the airline to develop an understanding of the reasons for the airline's unacceptable safety performance, especially the recurring noncompliance with procedures. (ASC-ASR-16-06-005)

To Civil Aeronautics Administration

1. Review airline safety oversight measures to ensure that safety deficiencies are identified and addressed in an effective and timely manner. (ASC-ASR-16-06-006)
2. Implement a highly robust regulatory oversight process to ensure that airline safety improvements, in response to investigations, audits, or inspections, are implemented in a timely and effective manner. (ASC-ASR-16-06-007)
3. Conduct a detailed review of the regulatory oversight of TransAsia Airways to identify and ensure that the known operational safety deficiencies, including crew noncompliance with procedures, nonstandard training practices, and unsatisfactory safety management, were addressed effectively. (ASC-ASR-16-06-008)
4. Provide inspectors with detailed guidance on how to evaluate the effectiveness of operator nontechnical training programs such as crew resource management (CRM) and threat and error management (TEM) training programs. (ASC-ASR-16-06-009)

To UTC Aerospace System Company

1. Work with the manufacturers of engine and aircraft to assess the current operating parameters and aircraft risks associated with the PW127 series engine auto feather unit (AFU) to minimize or prevent occurrences that could result in uncommanded autofeather. (ASC-ASR-16-06-010)

To Pratt & Whitney Canada

1. Work with manufacturers of the auto feather unit (AFU) and aircraft to assess the current operating parameters and aircraft risks associated with the PW127 series engine auto feather unit to minimize or prevent occurrences that could result in uncommanded autofeather. (ASC-ASR-16-06-011)

To Avions de Transport Régional

1. Work with manufacturers of the auto feather unit and engine to assess the current operating parameters and aircraft risks associated with the PW127 series engine auto feather unit (AFU) to minimize or prevent occurrences that could result in uncommanded autofeather. (ASC-ASR-16-06-012)
2. Publish in the flight crew operating manual (FCOM) an operational procedure related to rejected take off and expanded information regarding conditions leading to rejected take off. (ASC-ASR-16-06-013)

To European Aviation Safety Agency

1. Require a review at industry level of manufacturer’s functional or display logic of the flight director so that it disappears or presents appropriate orders when a stall protection is automatically triggered. (ASC-ASR-16-06-014)
2. Study the content and the duration of the minimum requirement regarding a differences training program between a conventional avionics cockpit and an advanced suite including enhanced automated modes for aircraft having the same type rating. (ASC-ASR-16-06-015)
3. Require a review of manufacturer's airplane flight manual (AFM) to ensure that a rejected take off procedure is also applicable to both engines operating. (ASC-ASR-16-06-016)