國家運輸安全調查委員會

重大運輸事故

調查報告

中華民國 108 年 5 月 2 日

華信航空股份有限公司 AE7931 班機

ATR72-212A 型機

國籍標誌及登記號碼 B-16851

於下降過程客艙短暫失壓

報告編號：TTSB-AOR-20-09-001

報告日期：民國 109 年 9 月

依據中華民國運輸事故調查法及國際民航公約第 13 號附約，本調查報告僅供改善飛航安全之用。

中華民國運輸事故調查法第 5 條：

運安會對於重大運輸事故之調查，旨在避免運輸事故之再發生，不以處分或追究責任為目的。

國際民航公約第 13 號附約第 3 章第 3.1 節規定：

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.

摘要報告

民國 108 年 5 月 2 日，華信航空股份有限公司一架 ATR72-212A 型客機，國籍標誌及登記號碼 B-16851，航班編號 AE7931，於 1432 時自高雄國際機場起飛，執行飛往花蓮機場之飛航任務，機上載有正、副駕駛員各 1 人、客艙組員 2 人、隨機機務 1 人、乘客 48 人，共計 53 人。該機於下降過程中「客艙高度過高」警告作動，經飛航組員處置後，於 1528 時降落花蓮機場，人機均安。

事故機於花蓮機場落地後，維修人員檢查發現該機空調地面連接單向閥自高雄機場起飛前可能已因閥門彈簧斷裂，使單向閥閥門無法維持在全關閉位置。本次事故發生前，華信並未將航空器製造廠發布之該單向閥技術進展狀況納入公司須正式評估之修護通告，亦未參考航空器製造廠發布之單向閥翻新改進資訊信函，更換改良設計的新型單向閥；相關檢查工單無使用地面外接冷氣車後，應檢查及確認空調地面連接單向閥在全關閉位置之說明。

航機起飛後爬升及巡航階段之發動機進氣量足以維持該機客艙高度，但在航機下降時發動機推力降到慢車，空調供氣量減少使航機客艙高度上升超過門檻值，因而觸發客艙高度過高警告，飛航組員緊急使用氧氣面罩並向航管宣告緊急情況之事故。

依據中華民國運輸事故調查法及國際民航公約第 13 號附約相關內容，國家運輸安全調查委員會（以下簡稱運安會）為負責本次飛航事故調查之獨立機關。受邀參與本次調查之機關（構）包括：法國航空器失事調查局、交通部民用航空局及華信航空股份有限公司。

本事故「調查報告草案」於 109 年 1 月完成，依程序於 109 年 5 月 1 日經運安會第 11 次委員會議初審修正後函送相關機關（構）提供意見；經彙整相關意見後，調查報告於 109 年 8 月 7 日經運安會第 14 次委員會議審議通過後，於 109 年 9 月 1 日發布調查報告。

本事故調查經綜合事實資料及分析結果，獲得之調查發現共計 6 項，無改善建議，如下所述。

壹、調查發現

與可能肇因有關之調查發現

1. 事故機自高雄機場起飛前，空調地面連接單向閥可能已經故障無法維持在全關閉位置，使航機加壓艙內與艙外大氣環境連通，航機自巡航高度下降過程中，客艙加壓系統受到當時飛行高度、空調系統進氣量下降及單向閥未關閉的影響，無法建立適當客艙壓力，導致觸發客艙高度過高警告。

與風險有關之調查發現

1. 本次事故發生前，華信並未評估航空器製造廠於 107 年 2 月發布之單向閥翻新改進資訊信函（RIL-2018-03），更換改良設計的新型單向閥。
2. 本次事故發生前，華信 Pre-flight、Transit 及 Daily check 工單無相關使用地面外接冷氣車後，應檢查及確認空調地面連接單向閥在全關閉位置之說明。
3. 事故機於飛航空層 130 巡航過程中，因機艙內部空氣自未閉合之單向閥門洩出機外，使客艙高度自約 2,000 呎逐漸上升至約 8,000 呎；飛航組員若曾於航機巡航期間檢查客艙高度之確切數值，應有機會提早發現客艙高度高於正常值。

其他調查發現

1. 事故航班飛航組員持有民航局頒發之有效航空人員檢定證與體檢證，飛航資格符合民航局與華信航空要求，訓練與考驗紀錄中查無與本案有關之異常發現。無證據顯示於本次事故中有足以影響飛航組員操作表現之酒精因素。
2. 事故機之適航與維護符合民航局及華信航空相關規範，本案除空調地面

連接單向閥發生故障外，其他航機系統及發動機均無異常。

貳、運輸安全改善建議

改善建議

無。

已完成之改善建議

華信航空股份有限公司

1. 於「ATR72-600 機型飛航組員訓練手冊」1.2.14 CLIMB-CRUISE 及 2.5.5 EMERGENCY DESCENT 章節中，增列不同飛航空層之參考客艙高度比較表及處置措施對照，以利飛航組員早期發現艙壓異常狀況，而能儘早處置。
2. 將本事件製作為簡報，包含 10,000 ft 檢查重點及客艙高度比較說明，於航務月訊中提供全體飛航組員研讀，以利飛航組員瞭解與學習類似事件的判斷及處理建議。
3. 修訂 ATR72-600 機型之 Pre-flight、Transit 及 Daily check 工單，若當班次飛機有使用外接冷氣車，當外接冷氣車撤離後，機務人員應確認 Air conditioning ground check valve 位置。
4. 本次事件飛機(B-16851)及其餘四架飛機(B-16852～B-16856)已於事件發生後更換為新型 Air conditioning ground check valve，避免 check valve fail in open 情況發生。
5. 於 ATR72-600 機型飛機維護計畫(AMP) 之 A check 項目增訂 Air conditioning ground check valve 檢查工項。

6. 針對品質程序 QP-MP-03「修護手冊、AD 及修護通告管理作業程序」增訂工程師評估 TPS 等修護通告之詳細作業程序，將 TPS 納入工程師須正式評估之修護通告；於 108 年 8 月 30 日完成所有 TPS 之評估，後續每月至 ATR 網站下載新發布之 TPS 進行評估。

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英文縮寫對照表

CVR	cockpit voice recorder	座艙語音紀錄器
EWD	engine warning display	發動機警告顯示
FCOM	flight crew operating manual	飛航組員操作手冊
FCTM	flight crew training manual	飛航組員訓練手冊
FDR	flight data recorder	飛航資料紀錄器
ILS	instrument landing system	儀器降落系統
PF	pilot flying	操控駕駛員
PM	pilot monitoring	監控駕駛員
PWC	Pratt & Whitney Canada	加拿大普惠公司
QRH	quick reference handbook	快速參考手冊
RIL	retrofit information letter	翻新改進資訊信函
SID	standard instrument departure	標準儀器離場程序
TPS	technical progress status	技術進展狀況
UTC	coordinated universal time	世界標準時間

本頁空白

第1章 事實資料

1.1 飛航經過

民國 108 年 5 月 2 日，華信航空股份有限公司（以下簡稱華信航空）一架 ATR72-212A[1]型客機，國籍標誌及登記號碼 B-16851，航班編號 AE7931，於 1432 時[2]自高雄國際機場（以下簡稱高雄機場）起飛，執行飛往花蓮機場之飛航任務，機上載有正、副駕駛員各 1 人、客艙組員 2 人、隨機機務 1 人、乘客 48 人，共計 53 人。該機於下降過程中「客艙高度過高」警告作動，經飛航組員處置後，於 1528 時降落花蓮機場，人機均安。

事故航班由正駕駛員坐於駕駛艙左座擔任操控駕駛員（pilot flying, PF），副駕駛員坐於駕駛艙右座擔任監控駕駛員（pilot monitoring, PM），該機自高雄機場 09 跑道起飛後，實施 HENGCHUN ONE（HN1）標準儀器離場程序（standard instrument departure, SID），接續沿 B591 航路向北飛行。1504:04 時，該機自飛航空層 130 之巡航高度下降過程中，位於 B591 航路上、距離花蓮機場南南西方約 36 浬處，駕駛艙主警示[3]作動，伴隨發動機警告顯示（engine warning display, EWD）上顯示「CAB ALT」警示，當時之氣壓高度為 11,890 呎，客艙高度為 9,398 呎。1504:17 時，正當飛航組員討論此一狀況期間，駕駛艙主警告[4]作動，伴隨 EWD 上顯示「EXCESS CAB ALT」警告，當時之氣壓高度為 11,629 呎，客艙高度為 9,833 呎，正駕駛員隨即下達緊急下降「EMERGENCY DESCENT」指令，飛航組員開始執行戴氧氣面罩及護目鏡、確認彼此通聯等程序，副駕駛員並於 1504:40 時向臺北近場臺宣告緊急情況（MAYDAY），該機持續下降高度。

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[1] ATR72-212A 為該型機設計型號，配備傳統儀表之銷售型號為 ATR72-500，配備新式儀表之銷售型號為 ATR72-600，事故航空器為 ATR72-600 型。

[2] 除非特別註記，本報告所列時間皆為臺北時間，即世界標準時間（coordinated universal time, UTC）加 8 小時，採 24 小時制，並以飛航資料紀錄器（flight data recorder, FDR）之時間為基準。

[3] Master caution.

[4] Master warning.

1504:45 時，客艙高度於上升至本航段最高之 10,241 呎後開始下降，至 1505:19 時，該機下降通過 10,284 呎氣壓高度、客艙高度 9,833 呎時，「EXCESS CAB ALT」警告解除。飛航組員於 1506:03 時向臺北近場臺管制員請求下降至 5,000 呎氣壓高度並取消緊急情況，隨後並取下氧氣面罩，保持 5,000 呎氣壓高度飛行以確認程序執行之完整性。

1514 時，飛航組員向臺北近場臺管制員請求雷達引導，執行花蓮機場 03 跑道儀器降落系統(instrument landing system, ILS)進場，於 1528 時降落花蓮機場，人機均安。事故航班飛航軌跡如圖 1.1-1。

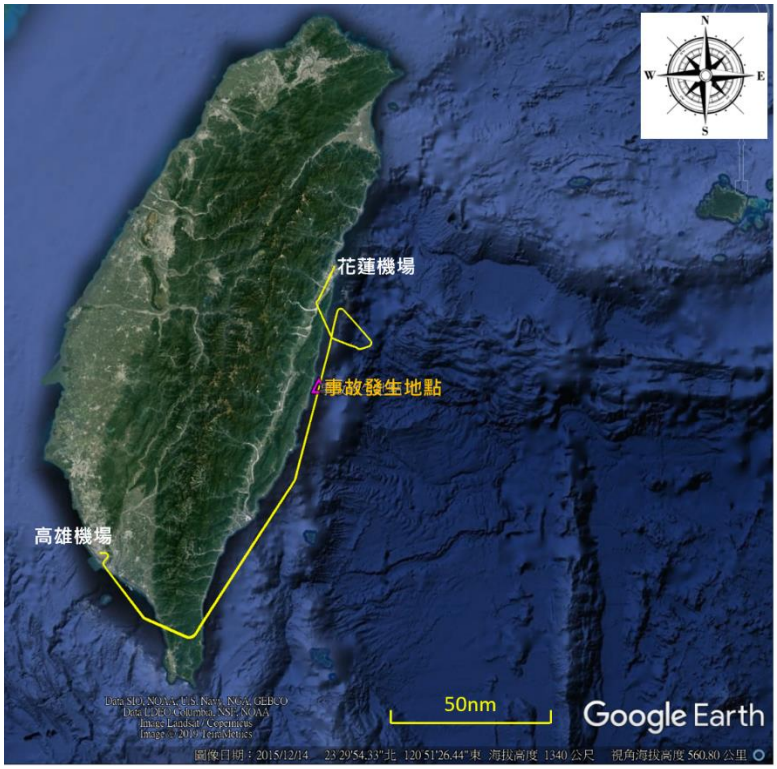

圖 1.1-1 事故航班飛航軌跡

1.2 人員傷害

無人員傷亡。

1.3 航空器損害情況

無相關議題。

1.4 其他損害情況

無相關議題。

1.5 人員資料

1.5.1 駕駛員經歷

飛航組員基本資料如表 1.5-1。

表 1.5-1 飛航組員基本資料表

項目	正駕駛員	副駕駛員
性別	男	男
事故時年齡	44	28
進入公司日期	民國 106 年 4 月	民國 107 年 3 月
航空人員類別	飛機民航運輸駕駛員	飛機商用駕駛員
檢定項目 發證日期 終止日期	ATR-72-600, A320 民國 106 年 12 月 7 日 民國 111 年 12 月 6 日	ATR-72-600 民國 107 年 7 月 26 日 民國 112 年 7 月 25 日
體格檢查種類 終止日期	甲類駕駛員 民國 108 年 9 月 30 日	甲類駕駛員 民國 108 年 7 月 31 日
總飛航時間[5]	7,587 小時 11 分	666 小時 56 分
事故型機飛航時間	1,129 小時 11 分	416 小時 56 分
最近 12 個月飛航時間	913 小時 06 分	416 小時 56 分
最近 90 日內飛航時間	219 小時 29 分	170 小時 39 分
最近 30 日內飛航時間	77 小時 03 分	63 小時 53 分
最近 7 日內飛航時間	22 小時 12 分	14 小時 27 分
事故前 24 小時飛航時間	4 小時 21 分	6 小時 24 分
派飛事故首次任務前之休息期間[6]	38 小時 03 分	16 小時 09 分

1.5.1.1 正駕駛員

中華民國籍，曾為軍機飛行員，退役後曾於其他航空公司擔任波音 B777、空中巴士 A320/321/330 等型機駕駛員。民國 106 年 4 月進入華信航空後，於 107 年 1 月完成 ATR72-600 機種轉換訓練並通過航路考驗之檢定後，於該機隊擔任正駕駛員。個人累計總飛時為 7,587 小時 11 分，其中

[5] 本表所列之飛航時間，均包含事故航班之飛行時間，計算至事故航班任務結束為止。

[6] 休息期間係指符合航空器飛航作業管理規則定義，「組員在地面毫無任何工作責任之時間」。

ATR72-600 型機飛時為 1,129 小時 11 分。

正駕駛員持有中華民國飛機民航運輸駕駛員檢定證，檢定項目欄內之註記為：「*飛機，陸上，多發動機 Aeroplane, Land, Multi-Engine, 儀器飛航 Instrument Rating ATR-72-600 A-320，具有於航空器上無線電通信技能及權限 Privileges for operation of radiotelephone on board an aircraft*」，限制欄內之註記為：「*空白 NIL*」，特定說明事項欄內之註記為：「*無線電溝通英語專業能力(Y-M-D) English Proficient: ICAO L4 Expiry Date 2021-07-29*」。

正駕駛員事故前最近一次年度適職性訓練時間為民國 107 年 10 月 28 日，內容包括客艙高度過高(EXCESS CAB ALT)及緊急下降(EMERGENCY DESCENT）等科目，訓練結果為「完成（completed)」；最近一次年度適職性考驗於民國 107 年 10 月 29 日通過，考驗結果為「通過（passed)」；最近一次年度實機考驗於民國 108 年 1 月 18 日通過。正駕駛員個人訓練與考驗紀錄經檢視後，無異常發現。正駕駛員體格檢查種類為甲類駕駛員，上次體檢日期為民國 108 年 3 月 15 日，體檢及格證限制欄內之註記為：「*視力需戴眼鏡矯正（Holder shall wear corrective lenses.)*」，事故當時依規定配戴眼鏡。事故後執行之酒精測試結果：酒精值為零。

1.5.1.2 副駕駛員

中華民國籍，自行赴美學習飛行，於民國 105 年 10 月取得美國飛機商用駕駛員執照，於民國 107 年 3 月進入華信航空，同年 11 月完成 ATR72-600 型機訓練並通過航路考驗之檢定後，於該機隊擔任副駕駛員。個人累計總飛時為 666 小時 56 分，其中學習駕駛員時數為 250 小時，ATR72-600 型機飛時為 416 小時 56 分。

副駕駛員持有中華民國飛機商用駕駛員檢定證，檢定項目欄內之註記為：「*飛機，陸上，多發動機 Aeroplane, Land, Multi-Engine,儀器飛航 Instrument Aeroplane ATR-72-600 具有於航空器上無線電通信技能及權限 Privileges for operation of radiotelephone on board an aircraft*」，限制欄內之

註記為：「*ATR-72-600 F/O*」，特定說明事項欄內註記為：「*無線電溝通英語專業能力(Y-M-D) English Proficient; ICAO L5 Expiry Date 2024-03-27*」。

副駕駛員事故前最近一次年度適職性訓練時間為民國 108 年 2 月 14 日，內容包括客艙高度過高(EXCESS CAB ALT)及緊急下降(EMERGENCY DESCENT）等科目，訓練結果為「完成（completed)」；最近一次年度適職性考驗於民國 108 年 2 月 15 日通過，考驗結果為「通過（passed)」。副駕駛員個人訓練與考驗紀錄經檢視後，無異常發現。副駕駛員體格檢查種類為甲類駕駛員，上次體檢日期為民國 107 年 7 月 17 日，體檢及格證限制欄內註記為：「*視力需戴眼鏡矯正*（*Holder shall wear corrective lenses.*)」，事故當時依規定配戴眼鏡。事故後執行之酒精測試結果：酒精值為零。

1.6 航空器資料

1.6.1 航空器與發動機基本資料

事故航空器基本資料統計至民國 108 年 5 月 1 日，如表 1.6-1。

表 1.6-1 航空器基本資料

航空器基本資料表	
國籍	中華民國
國籍標誌及登記號碼	B-16851
機型	ATR72-212A
製造廠商	ATR-GIE Avions de Transport Régional
出廠序號	1460
出廠日期	民國 106 年 11 月 24 日
交機日期	民國 106 年 11 月 24 日
所有人	Avation Taiwan Leasing II Pte. Ltd.
使用人	華信航空股份有限公司
國籍登記證書編號	106-1523
適航證書編號	107-11-242
適航證書有效期限	民國 108 年 11 月 15 日
總使用時數	2,865 小時 57 分
總落地次數	4,393 次
上次定檢種類及日期	PA6 定檢/民國 108 年 4 月 22 日
上次定檢後使用時數	56 小時 50 分
上次定檢後落地次數	89 次

事故機裝有 2 具加拿大普惠公司（Pratt & Whitney Canada，以下簡稱 PWC）之 PW127M 型發動機，資料統計至民國 108 年 5 月 1 日，詳表 1.6-2。

表 1.6-2 發動機基本資料

發動機基本資料表		
編號/位置	No. 1/左	No. 2/右
製造商	PWC	PWC
型號	PW127M	PW127M
序號	PCE-ED1516	PCE-ED1517
製造日期	民國 106 年 4 月 23 日	民國 106 年 4 月 24 日
裝機後使用時數	2,865 小時 57 分	2,865 小時 57 分
裝機後使用週期	4,393 次	4,393 次

1.6.2 航機維修資訊

檢視該機事故前 3 個月內維護紀錄簿（technical log book）及延遲改正缺點紀錄，無與艙壓控制系統相關之異常登錄。檢視適航指令及技術通報均符合相關規定。事故發生前最近一次定期檢查（PA6 check[7]）紀錄，無異常紀錄。查閱該機事故航班前之維修紀錄，顯示該機自高雄機場派飛時，無最低裝備需求手冊（minimum equipment list）之故障項目，亦無缺點報告或延遲改正事項。

1.6.3 艙壓系統與空調地面連接單向閥

事故機於飛航過程中發生艙壓異常狀況，航機降落花蓮機場後，地面維修人員依維修手冊檢查航機，發現件號為 41125A01 之空調地面連接單向閥（ground connection check valve）故障，無法維持在全關閉位置（如圖 1.6-1 所示），同時檢查發現閥門下游之空調分布管凹陷受損。維修人員依維修手冊更換該閥門及其下游之空調分布管，經檢查測試後，航機恢復正常。

[7] PA6 check 表第 6 次 A 級定檢，A 級定檢之間隔為 500 飛時，PA6 check 於航機使用時數為 3,000 飛時時執行。

圖 1.6-1 空調地面連接單向閥失效位置

空調地面連接單向閥裝置位於機腹右側，位置如圖 1.6-2 所示，裝備代號 6352HQ 所示，外觀如圖 1.6-3，其功能為當航機地停時，將機外空調系統連接此單向閥，可經由空調管將機外空調空氣供應至客艙及駕駛艙。

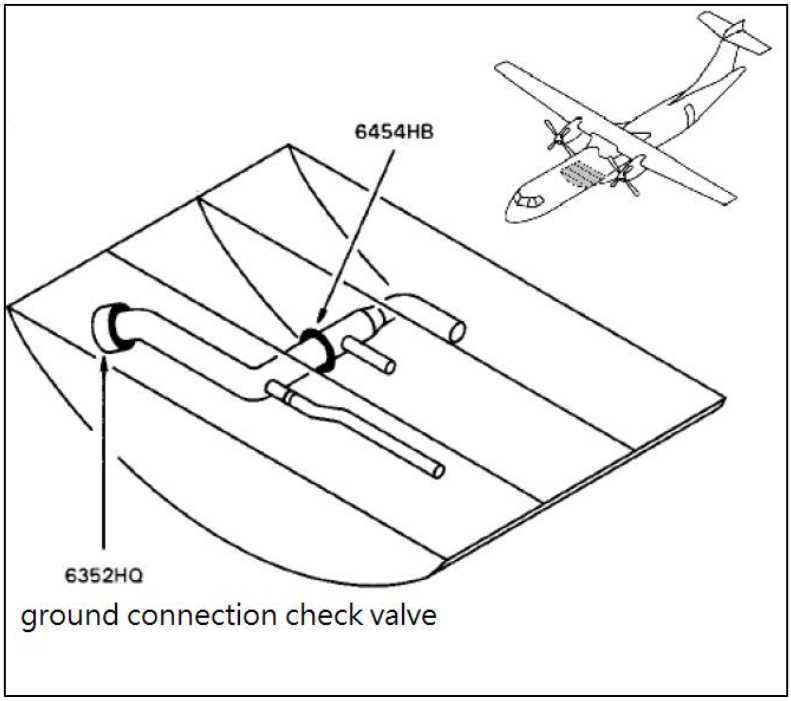

圖 1.6-2 空調地面連接單向閥裝置位置

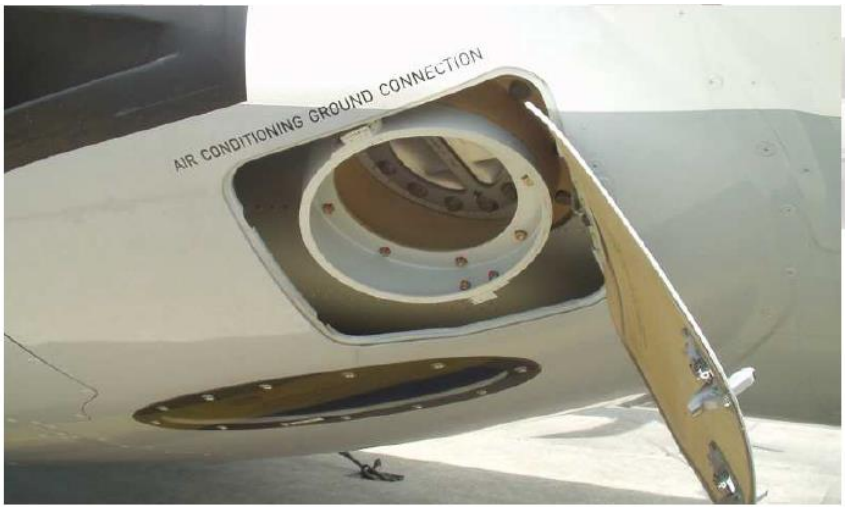

圖 1.6-3 空調地面連接單向閥外觀

航空器製造廠於 104 年 10 月以編號 TPS 21-22-001 發布技術進展狀況（technical progress status, TPS），其內容顯示件號 41125A01 之空調地面連接單向閥，曾發生因為閥門彈簧失效，造成閥門無法維持在全關閉位置，其結果可能使飛機艙壓無法建立，並可能在艙壓發生異常時，因為機艙內外差壓，使該閥門下游之空調分布管凹陷受損。為避免此狀況發生，製造廠建議在每次使用地面空調後，移除地面空調導管時，檢查此閥門的位置，

並確保單向閥在關閉的位置；本項 TPS 最近一次更新版本為第 8 版，發布日期為 107 年 4 月。

航空器製造廠曾於 107 年 2 月以編號 RIL-2018-03 發布該單向閥之翻新改進資訊信函（retrofit information letter, RIL），提供改良設計的新單向閥（件號 41125A020001），此新件號單向閥與事故機裝用件號為 41125A01 之單向閥完全相容，可以互換。

1.7 天氣資訊

無相關議題。

1.8 助、導航設施

無相關議題。

1.9 通信

無相關議題。

1.10 場站資料

無相關議題。

1.11 飛航紀錄器

1.11.1 座艙語音紀錄器

該機裝置固態式座艙語音紀錄器（cockpit voice recorder, CVR），製造商為 L-3 Aviation Products 公司，件號為 2100-1225-22。該座艙語音紀錄器具備 2 小時高品質錄音記錄能力，聲源分別來自正駕駛員麥克風、副駕駛員麥克風、廣播系統麥克風及座艙區域麥克風。CVR 下載情形正常，錄音品質良好。CVR 所記錄之語音資料共 124 分 14.5 秒，包含事故航班飛機起飛、巡航、進場、發生事故與落地等過程，調查小組針對本事故製作了約 12

分鐘的抄件。

1.11.2 飛航資料紀錄器

該機裝置固態式飛航資料紀錄器（flight data recorder, FDR），製造商為 L-3 Aviation Products 公司，件號為 2100-4245-00。事故發生後，本會依據飛機製造商飛航資料解讀文件進行解讀，該飛航資料紀錄器可儲存 60 小時 46 分鐘 37 秒資料，共記錄 1,008 項參數，所有參數以世界標準時間（UTC）時間[8]為基準。與事故相關之 FDR 解讀資料摘錄如下：

1. 臺北時間 1424 時，FDR 開始記錄。
2. 臺北時間 1432 時，該機自高雄機場起飛。
3. 臺北時間約 1502:30 時，航機氣壓高度 12,950 呎，客艙高度從約 8,000 呎左右開始上升。
4. 臺北時間 1504:17 時，主警告燈亮，此時航機氣壓高度 11,629 呎，客艙高度 9,833 呎，駕駛艙顯示程序為「excess cabin altitude」。
5. 臺北時間 1504:45 時，航機氣壓高度 11,090 呎，客艙高度達到本航段最高之 10,241 呎。
6. 臺北時間 1505:19 時，航機通過氣壓高度 10,284 呎，於客艙高度 9,833 呎時，「EXCESS CAB ALT」警告解除。
7. 臺北時間 1528:50 時，該機於花蓮機場落地。
8. 臺北時間 1534 時，FDR 停止記錄。

有關該機飛航軌跡如圖 1.1-1，飛航資料紀錄有關飛航參數繪圖詳圖 1.11-1。

[8] UTC 時間 ＋8 小時 ＝ 臺北時間。

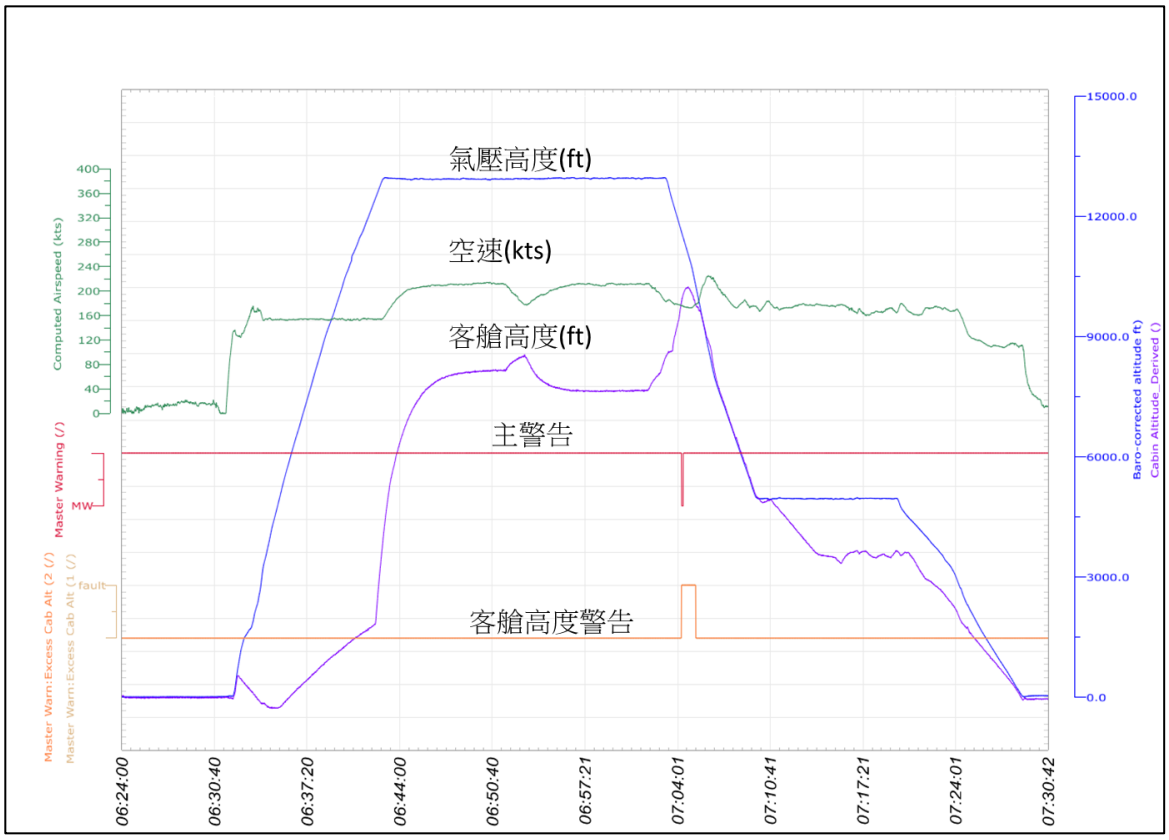

圖 1.11-1 事故機 FDR 相關參數繪圖

1.12 航空器殘骸與撞擊資料

無相關議題。

1.13 醫學與病理

無相關議題。

1.14 火災

無相關議題。

1.15 生還因素

無相關議題。

1.16 測試與研究

無相關議題。

1.17 組織與管理

無相關議題。

1.18 其他資訊

1.18.1 飛航操作相關手冊內容

1.18.1.1 快速參考手冊

華信航空 ATR72-600 機型快速參考手冊[9]（quick reference handbook, QRH）與本事故有關之內容計有：CABIN ALTITUDE、EXCESS CAB ALT 及 EMERGENCY DESCENT，摘錄如下：

A21.08	CABIN ALTITUDE
► CABIN ALTITUDE : MONITOR	

[9] 版期 REV 0 TR02，生效日期 2019 年 1 月 16 日。

EXCESS CAB ALT	A21.10

► CAB PRESS indicator .....CHECK
■ **If rapid decompression**
► AFM - EMERGENCY DESCENT procedure (E99.04) .....APPLY
■ **If cabin altitude > 10 000 ft confirmed**
► CAB PRESS RATE knob .....9 O'CLOCK (MAN POSITION)
► CAB PRESS MODE SEL..... MAN
► CAB PRESS RATE knob ..... DECREASE
■ **If EXCESS CAB ALT persists**
► CREW OXY MASKS..... DON
► CREW COMMUNICATIONS.....ESTABLISH
► OXYGEN PAX SUPPLY..... AS RQRD
► OXYGEN PRESSURE.....CHECK
► DESCENT.....INITIATE AS RQRD
► MAX FL : 100/MEA

E99.04	EMERGENCY DESCENT

► CREW OXY MASKS..... AS RQRD
► CREW COMMUNICATIONS.....AS RQRD
► GOGGLES.....AS RQRD
► DESCENT..... INITIATE
► PL 1+2..... FI
► CL 1+2.....100% OVRD
► OXYGEN PAX SUPPLY..... AS RQRD
► IAS : VMO/MMO (or less if structural damage is suspected)
► SIGNS.....ON
► ATC..... NOTIFY
► MEA..... CHECK

1.18.1.2 飛航組員操作手冊

華信航空 ATR72-600 機型飛航組員操作手冊[10]（flight crew operating manual, FCOM）與本事故有關之內容計有：AUTO PRESS FAULT-Alert、EXCESS CAB ALT-Alert、CABIN ALTITUDE-Alert 及 AUTO PRESS FAULT，摘錄如下：

[10] 版期 REV 0 TR01，生效日期 2019 年 1 月 16 日。

4.1 AUTO PRESS FAULT-Alert

_27a18dfe-790a-4f8f-b610-1237d44c51d6 2.4

ALL

CONDITION	VISUAL	AURAL
Digital controller failure	- MC light flashing amber - AIR AUTO PRESS amber message on EWD - FAULT amber light on CAB PRESS MOD SEL pb - AUTO PRESS amber message on Cabin SD page	SC

「AUTO PRESS FAULT」觸發條件為：數位控制器失效時。

4.3 EXCESS CAB ALT-Alert

_481be014-82ee-47ff-9fc3-e10042ee6fbe 0.2

ALL

CONDITION	VISUAL	AURAL
Cabin altitude > 10 000 ft (15 000 ft in High Altitude mode)	- MW light flashing red - EXCESS CAB ALT red message on EWD - Red reverse video ALT flashing on Air Cabin SD page	CRC

「EXCESS CAB ALT-Alert」觸發條件為：客艙高度大於 10,000 呎（高高度模式為大於 15,000 呎）。

4.4 CABIN ALTITUDE-Alert

_4c828a69-264b-4dab-a623-a97b9742f79d 0.2

ALL

CONDITION	VISUAL	AURAL
9 500 ft < Cabin altitude < 10 000 ft - OR - 14 000 ft < Cabin altitude < 15 000 ft (in High Altitude mode)	- MC light flashing amber - CAB ALT amber message on EWD	SC

「CABIN ALTITUDE-Alert」觸發條件為：客艙高度大於 9,500 呎、小於 10,000 呎，或客艙高度大於 14,000 呎、小於 15,000 呎（高高度模式下）。

AUTO PRESS FAULT

940538b9-f542-468b-9d3f-202570c694de 3.2
ALL

AUTO PRESS FAULT

► CAB PRESS RATE knob .....9 O'CLOCK (MAN position)
► CAB PRESS MODE SEL ..... MAN
► CAB PRESS RATE knob .....AS RQRD TO ADJUST TARGET CAB ALT

FL	140	170	200	220	240	250
TARGET CAB ALT (ft)	2 500	3 300	4 200	5 200	6 200	6 800

● Before descent
■ If CAB ALT above landing elevation
► CAB PRESS RATE knob .....DECREASE
► CAB ALT RATE..... ADJUST 400 ft/min DN
■ If CAB ALT below landing elevation
► CAB PRESS RATE knob .....INCREASE
► CAB ALT RATE..... ADJUST 1 000 ft/min UP MAX
● When CAB ALT = landing elevation
► CAB PRESS RATE knob .....9 O'CLOCK (MAN position) & MONITOR
● After landing
► CAB PRESS RATE knob ..... MAX INCREASE

當「AUTO PRESS FAULT」狀況發生時，飛航組員應以手動模式調控艙壓；該程序並列舉不同飛航空層下之客艙高度目標值，以飛航空層 140 為例，客艙高度目標值為 2,500 呎。

1.18.1.3 飛航組員訓練手冊

華信航空 ATR72-600 機型飛航組員訓練手冊[11]（flight crew training manual, FCTM）第 1.2 節 Standard Operation Procedures（標準作業程序）有關爬升與巡航之程序，如下所示：

[11] 版期 REV 3，生效日期 2019 年 4 月 22 日。

1.2.14 CLIMB – CRUISE

Flight events	PM	PF
PASSING 10,000 or REACHING CRUISE ALTITUDE	▶CALL "TEN THOUSAND" ▶DO ALL SYSTEM PAGES ..... CHECK DURING CLIMB ..... ALL SYSTEMS SCAN PRESSURIZATION ..... MONITOR Check ΔP, CAB ALT, and CAB RATE on SD page. CM1 LANDING LIGHTS ..... OFF WING LIGHTS ..... OFF	▶CALL "CHECK"
1,000FT TO LEVEL OFF	▶ANNOUNCE "ONE THOUSAND"	▶CALL "CHECK"
APPROACHING CRUISE LEVEL/ ALTITUDE	DELTA ISA ..... CHECK FMA ..... X CHECK ▶CALL "CHECK" ▶CALL "CHECK"	FMA ..... MONITOR FL/ALT INTERCEPTION ▶CALL "ALT STAR" ▶CALL "ALT GREEN"
AT CRUISE FL/ ALT	SPEED BUG ..... CHECK ▶CALL "CHECK"	SPEED BUG ..... CHECK ▶CALL "SPEED XXX MAGENTA"
10 KTS BEFORE CRUISE SPEED	▶DO PWR MGT SELECTOR ..... CRZ TQ BUGS ..... CHECK CRUISE PARAMETERS ..... MONITOR Confirm TQ, FF, IAS, and TAS match with ▶CALL "CRUISE POWER SET"	▶CALL "SET CRUISE POWER" CRUISE PARAMETERS ..... MONITOR Confirm TQ, FF, IAS, and TAS match with expected cruise parameters ▶CALL "CHECK"
DURING CRUISE	SYSTEMS ..... MONITOR PERIODICALLY DEST REMAINING FUEL ..... CHECK FMS PREDICTIONS ..... CHECK WPT, DEST ETA, TOD, DEST RAIM, and EFOB	TOP OF DESCENT ..... CHECK REMAINING FUEL & HOLDING TIME .... MONITOR
IF ENCOUNTER TURBULANCE	REFER TO FCOM/ FOM	

其中飛航組員應於航機爬升通過 1 萬呎或到達巡航高度時，監控客艙加壓狀況，檢查系統顯示頁面上客艙與外界之壓差（△P）、客艙高度及客艙高度變化率；巡航過程中，應定期監控各系統頁面。

1.18.2 訪談資料

1.18.2.1 正駕駛員訪談摘要

事故當次任務為正駕駛員當日第 5 趟次飛航任務，由正駕駛員坐於駕駛艙左座擔任 PF，自高雄機場起飛後按正常程序離場，爬升至接近巡航高度飛航空層 130 時，客艙組員向駕駛艙反映左發動機聲音特別大，故詢問

是否有什麼問題；飛航組員檢查各系統參數後發現一切正常，隨機機務人員前去該區域觀察後，亦表示應無異狀。

隨後航管許可該機自飛航空層 130 下降，執行花蓮機場 03 跑道儀器降落系統（ILS）進場，並告知通過 ARBOR 航點時須保持 5,000 呎高度以上；正駕駛員將高度設定為最後進場點（final approach fix）高度 2,100 呎，使用 LNAV-VNAV[12]模式下降，下降率約為 1,200 呎/分左右。下降通過 1 萬 900 呎時，發動機警告顯示（EWD）上出現琥珀色「CAB ALT」警示，副駕駛員檢查儀表並報讀客艙高度數值為 8,900 呎，很快上升至 9,900 呎並隨即觸發「EXCESS CAB ALT」紅色警告，當時該機的高度約為 1 萬 600 呎左右。

正駕駛員隨即下達緊急下降「EMERGENCY DESCENT」指令，飛航組員依該程序執行戴氧氣面罩、戴護目鏡、確認飛航組員彼此間通聯狀況等記憶項目，通知客艙組員緊急下降，並向航管宣告緊急情況（MAYDAY），請求下降高度至 5,000 呎。由於狀況發生前該機原已在下降過程中，故當飛航組員完成上述程序後，EWD 上之警示與警告皆已解除，客艙高度回復至正常範圍，該機高度亦低於 1 萬呎以下，也因此認為無施放客艙氧氣面罩之必要。考慮到當時接近海岸山脈附近，下方地障受雲層遮蔽無法目視，因此正駕駛員決定維持原本 LNAV 模式下降，未以大下降率下降高度。

下降至 6,000 呎高度左右，正駕駛員認為當時已無失壓威脅，故請副駕駛員先取下氧氣面罩，確認狀況無虞後，正駕駛員亦取下氧氣面罩。隨後飛航組員詢問客艙狀況，於 5,000 呎高度改平，確認方才執行緊急程序之過程中是否有所遺漏；完成後向航管取消緊急情況並申請重新進場，管制員以雷達引導，1528 時安降花蓮機場。

事故當日航機狀況正常，維護紀錄簿上除了艙門刮傷及與雷達罩有關

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[12] LNAV：橫向導航（lateral navigation），飛機區域航行裝備中用以計算、顯示並提供相關水平方位圖解或飛行路線引導。VNAV：垂直導航（vertical navigation），飛機區域航行裝備中用以計算、顯示並提供相關垂直方位圖解或飛行路線引導。

之註記外，並無其他足以影響操作之延遲改正缺點。事故當次任務起飛爬升通過 1 萬呎高度後，飛航組員曾檢查各系統頁面，包含加壓系統在內所有系統數值顯示皆為綠色，代表位於正常範圍內，但客艙高度、△P 等確切數值並未特別記下；空調與加壓系統於事故發生前無異狀，任務期間皆維持自動模式，未曾以手動方式控制。

華信 ATR72-600 型機平日用於飛航國內航線時，最大巡航高度約為 1 萬 4,000 呎。模擬機訓練的艙壓失效科目，曾模擬於 2 萬 5,000 呎高度爆炸減壓的情境，亦曾模擬逐漸失壓的情形，但最終皆會執行緊急下降程序。

正駕駛員認為自己當時的身心狀況尚可，並認為副駕駛員於事故過程中所應具備的程序執行、相互提醒與溝通皆表現良好。

1.18.2.2 副駕駛員訪談摘要

事故當次任務係副駕駛員當日第 1 趟次飛航任務，由其坐於駕駛艙右座擔任 PM，1431 時自高雄機場起飛後按 HENGCHUN ONE（HN1）標準儀器離場程序（SID）離場，爬升通過 1 萬呎高度後，客艙長曾向駕駛艙詢問 1 號發動機是否異常，因為客艙組員聽到「沙沙」聲，過去未曾聽過這樣的聲音。飛航組員檢查 4 個系統頁面後，發現發動機滑油壓力、溫度、轉數等數值都位在正常綠線範圍內，兩側發動機唯一的差別是油耗，1 號是 370，2 號是 365，另 1 號油箱之油量較 2 號油箱少了 40 公斤，但仍在容許範圍內。客艙高度及△P 亦位在正常綠線範圍內，但確切數值並未特別記下。隨行機務人員前去該區域觀察後，亦表示正常，因此便繼續飛行。

爬升至巡航高度飛航空層 130 後，飛航組員向航管要求直飛 ARBOR 航點並獲得同意，隨後航管許可該機下降，執行花蓮機場 03 跑道儀器降落系統（ILS）進場，正駕駛員將高度設定為最後進場點（final approach fix）高度 2,100 呎，使用 LNAV-VNAV 模式進場。

下降通過 1 萬 900 呎時，駕駛艙發出主警示（master caution），發動機

警告顯示（EWD）上顯示「CAB ALT」，副駕駛員依程序檢查儀表時，看見客艙高度數值為 8,900 呎，隨即上升至 9,900 呎、1 萬 600 呎並觸發「EXCESS CAB ALT」紅色主警告（master warning），當時該機高度約為 1 萬 600 呎，與客艙高度一致，代表客艙已未建壓。

正駕駛員隨即下達緊急下降「EMERGENCY DESCENT」記憶項目指令，並由副駕駛員向航管宣告緊急情況（MAYDAY）；由於該機原已在下降過程中，故俟飛航組員依該程序戴上氧氣面罩及護目鏡、確認飛航組員彼此間通聯狀況、並向航管宣告緊急情況後，EWD 上之警告與程序畫面皆已解除。為避免靠近山區，遂向航管提出取消進場許可，請求下降高度至 5,000 呎。下降至 5,000 呎後，確認已完成所有程序，飛機狀態平穩無操作上之疑慮，遂向航管取消緊急情況並申請重新進場。

執行事故當次任務起飛前檢查時，航機狀況正常，維護紀錄簿上無特殊註記，操作上沒要需要特別顧慮之處。空調與加壓系統於事故發生前無異狀，任務期間皆維持自動模式，未曾以手動方式控制。

副駕駛員認為事故當時自己雖有點緊張，但身心狀況仍足以應付當時的情形，無疲勞現象，正駕駛員的操作表現亦屬正常。

1.18.3 事件序

本事故發生之重要事件順序詳如表 1.18-1。

表 1.18-1 事件序列表

時間	事件	資料來源
1432	自高雄機場起飛	FDR
1443	爬升至巡航高度（飛航空層130）	FDR
1503	自巡航高度開始下降	FDR
1504:04	氣壓高度11,890呎，客艙高度9,398呎，駕駛艙主警示（master caution）作動，伴隨發動機警告顯示（EWD）上顯示「CAB ALT」警示	FDR, CVR
1504:17	氣壓高度11,629呎，客艙高度9,833呎，駕駛艙主警告（master warning）作動，伴隨EWD上顯示「EXCESS CAB ALT」警告	FDR, CVR
1504:21	正駕駛員下達緊急下降「EMERGENCY DESCENT」指令，飛航組員開始執行戴氧氣面罩及護目鏡、確認彼此通聯等程序	CVR
1504:40	副駕駛員向臺北近場臺宣告緊急情況（MAYDAY），該機按原導航模式持續下降	CVR
1504:45	客艙高度於上升至本航段最大值10,241呎後開始下降	FDR
1505:19	下降通過10,284呎氣壓高度、客艙高度9,833呎時，「EXCESS CAB ALT」警告解除	FDR
1506:03	飛航組員向管制員請求下降至5,000呎氣壓高度並取消緊急情況，隨後並取下氧氣面罩保持5,000呎氣壓高度飛行以確認程序執行之完整性	CVR
1514	飛航組員向管制員請求雷達引導，執行花蓮機場03跑道儀器降落系統（ILS）進場	CVR
1528	於花蓮機場落地	FDR

第2章 分析

2.1 概述

事故航班飛航組員持有民航局頒發之有效航空人員檢定證與體檢證，飛航資格符合民航局與華信航空要求，訓練與考驗紀錄中查無與本案有關之異常發現；無證據顯示於本次事故中有足以影響飛航組員操作表現之酒精因素。

依事故機維修資訊，事故前三個月內該機維護紀錄簿、飛機定檢工單均無與事故相關系統之異常登錄，有關適航指令項目亦依規定執行完成。事故航班自高雄機場放飛時無最低裝備需求手冊之故障項目，亦無延遲改正缺點項目。檢視事故航班 FDR 及 CVR 紀錄，除客艙加壓系統之異常狀況外，其他飛機系統及發動機均無異常紀錄。

2.2 客艙加壓系統

機務相關分析將依客艙加壓系統異常可能原因及影響、航空器製造廠改善資訊以及華信航空改善措施分述如後。

2.2.1 客艙加壓系統異常狀況分析

事故機於事故航班前曾在高雄機場地停時使用地面空調機，依據事故後航機於花蓮機場地面檢查之發現，空調地面連接單向閥閥門上施予閥門葉片壓力之彈簧斷裂，閥門無法維持在全關閉位置。此單向閥連接加壓艙內與艙外，在航機地停時，地面空調機管路接上單向閥後可提供空調空氣至航機客艙及駕駛艙。此閥門正常工作時，空調空氣由機外往機內單向流通，當撤離地面空調機管路後，閥門葉片因有彈簧加壓，閥門會自動回復到關閉位置；當機艙開始加壓時，因機艙內外壓差，此閥門亦會保持於關閉狀態。

依據事故後航機之檢視發現，施予閥門葉片壓力將閥門關閉之彈簧斷裂，致閥門無法維持在全關閉位置，當閥門未關閉時，如同將飛航中已加壓之飛機機艙與艙外大氣環境接通，造成機艙內部空氣自未閉合之單向閥門洩出機外，在發動機供氣量較少狀況下，會使飛機客艙高度增加，無法保持額定之客艙壓力。

在空調地面連接單向閥未關閉狀況下，飛機客艙加壓系統性能會受到飛行高度及發動機供氣狀況之影響；依據事故航班 FDR 資料，在起飛及爬升階段，發動機推力較大，供氣量足以維持該機客艙高度在 2,000 呎以下（如圖 2.2-1A 點以前）；事故機到達巡航高度（13,000 呎）後，發動機推力下降同時使空調系統進氣量下降，導致航機客艙高度上升（圖 2.2-1A 點以後），惟仍控制在約 8,000 呎；但是在該機脫離巡航階段後（圖 2.2-1B 點），發動機推力降到慢車，空調供氣量再減少使航機客艙高度急速上升，約 2 分 30 秒後，於 1504:17 時發生客艙高度過高警告。

綜上所述，航機在起飛前，空調地面連接單向閥可能已經故障無法維持在全關閉位置，使該機加壓艙內與艙外大氣環境連通，航機自巡航高度下降過程中，客艙加壓系統受到當時飛行高度、空調系統進氣量下降及單向閥未關閉的影響，無法建立適當客艙壓力，導致觸發客艙高度過高警告。

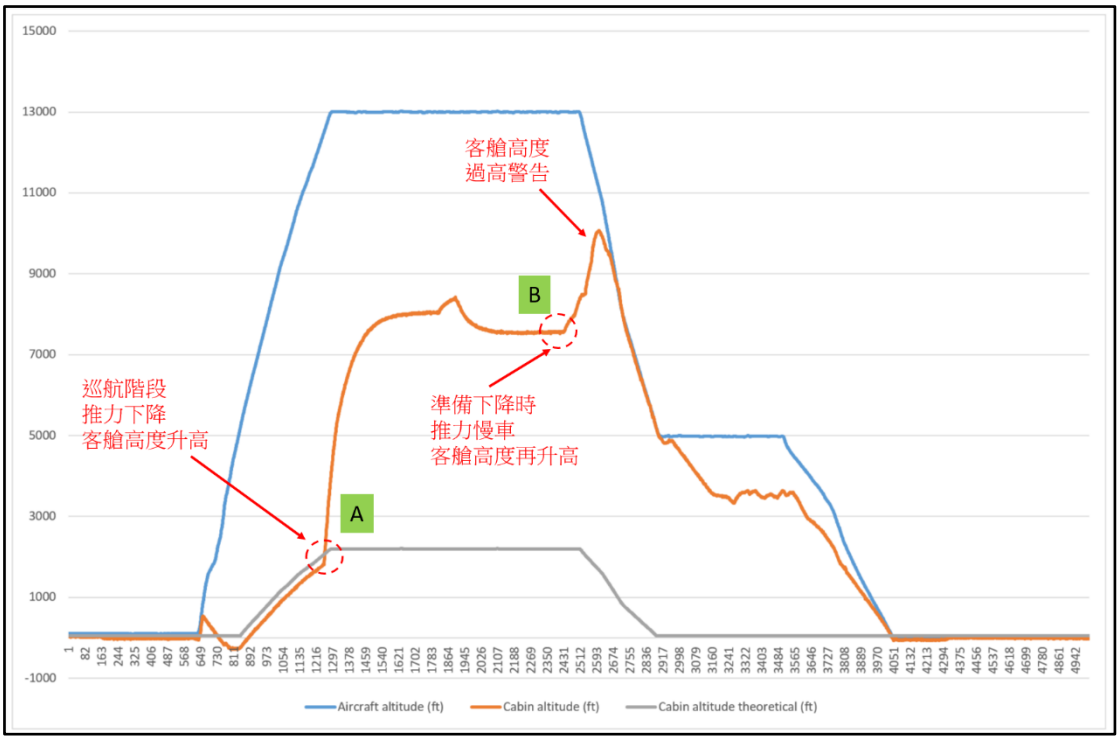


圖 2.2-1 客艙高度與相關資料繪圖

2.2.2 空調地面連接單向閥改善資訊

依據航空器製造廠編號 TPS 21-22-001 之技術進展狀況資訊，事故機所安裝之空調地面連接單向閥（件號 41125A01），過去亦曾發生因為閥門彈簧失效，造成閥門無法維持在全關閉位置，使飛機無法建立艙壓的狀況。為避免此狀況發生，航空器製造廠建議，在每次連接使用地面空調後，於移除地面空調管路時，檢查此閥門並確保單向閥在關閉的位置，本次事故前，華信航空事故型機日常性檢查並無空調地面連接單向閥之檢查說明。

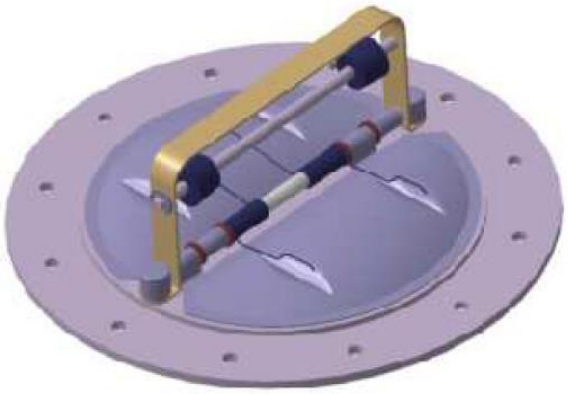
航空器製造廠曾於 107 年 2 月發布該單向閥之翻新改進資訊信函(RIL-2018-03)，提供改良設計的新單向閥（件號 41125A020001）。依 RIL-2018-03 之資訊，此改良後之單向閥可增進零件可靠度，並可避免因閥門彈簧失效後造成的客艙失壓，其設計之特點包含：

- 增加了兩個裝置，以使閥門葉片保持在穩定的位置
- 增加中央止點消除顫動現象

• 在軸和彈簧之間塗有特氟龍塗層的墊片

改良後之單向閥與原單向閥（件號 41125A01）可互換使用，此二單向閥外觀示意圖如圖 2.2-2。

原件號 41125A01



改裝後件號 41125A020001

圖 2.2-2 原單向閥（圖左）與改良後單向閥（圖右）

有關上述製造廠之建議檢查作為及翻新改進產品之資訊，事故後華信航空提供本會有關之改善措施如下：

- *本次事件飛機(B-16851)已於事件發生後更換新型 Air conditioning ground check valve，其餘 4 架 ATR72(B-16852～B-16856 機)於 2019 年 5 月 14 日~5 月 15 日執行更換新型 check valve；本公司今年引進之新機(B-16857、B-16858)出廠時已配置新型 check valve(standard modification)。*

- *依 TPS 21-22-001 建議，機務部已於 2019 年 5 月 3 日修訂 Pre-flight、Transit 及 Daily check 工單，增列 NOTE：若當班次飛機有使用外接冷氣車，當外接冷氣車撤離後，機務人員應確認 Air conditioning ground check valve 在 Fully close 位置。*

- *除依 MPD/AMP C check ZL192-GVI-100000-1 執行檢查項目外，另納*

入 AMP 每 500 FH 執行 Visual check of Air Ground Connection check Valve(ItemNo. 212251-99-1)。

有關空調地面連接單向閥故障可能導致飛機無法建立艙壓之問題，航空器製造廠已提供相關改善資訊，華信航空亦已評估該資訊，採取對應之改善作為，除對空調地面連接單向閥增加日常性檢查及 500 飛時定檢外，該事故機型之機隊並已全面更新改良之單向閥。因此，有關本案空調地面連接單向閥故障可能導致飛機無法建立艙壓之議題，調查小組無相關安全改善建議。

2.3 客艙高度之監控與異常狀況處置

依據事故當時有效版本之「華信航空 ATR72-600 機型飛航組員訓練手冊」，飛航組員應於航機爬升通過 1 萬呎或/及巡航期間，監控駕駛艙各系統頁面，其中包括客艙與外界之壓差（△P）、客艙高度及客艙高度變化率之狀況。

CVR 抄件及訪談紀錄顯示，飛航組員於該機爬升通過 1 萬呎氣壓高度後，曾依上述規定檢查駕駛艙各系統頁面，當時包括空調與加壓系統在內，所有數值皆顯示綠色或位於綠線（green band）範圍內，飛航組員因此認為各系統均正常運作，亦未特別關注客艙高度之確切數值。

依據「華信航空 ATR72-600 機型飛航組員操作手冊」，航機於飛航空層 140 巡航時之客艙高度目標值為 2,500 呎，據此，正常情況下該航班於飛航空層 130 巡航時之客艙高度應略低於 2,500 呎。然 FDR 資料顯示，該機於飛航空層 130 巡航過程中，客艙高度約自 2,000 呎逐漸上升，至航機下降高度前客艙高度約為 8,000 呎；飛航組員若曾於航機巡航期間檢查客艙高度之確切數值，應有機會提早發現客艙高度高於正常值。

飛航組員於該機開始下降時將發動機推力減低至慢車，使空調供氣量再減少，因而造成航機客艙高度再上升並觸發「CAB ALT」警示，此時飛

航組員始獲知異狀，檢查客艙高度已升高至 9,900 呎，並隨即觸發「EXCESS CAB ALT」警告，飛航組員因此認為當時是快速失壓，進而立即執行緊急下降程序。

本次事故後，華信航空已修訂事故機型飛航組員訓練手冊，於 1.2.14 CLIMB-CRUISE 及 2.5.5 EMERGENCY DESCENT 章節中增列不同飛航空層之參考客艙高度比較表及處置措施對照，以利飛航組員早期發現艙壓異常狀況，並儘早處置；華信航空並將此事件製作為簡報，於航務月訊中提供全體飛航組員研讀。據此，調查小組針對本案無飛航操作相關安全改善建議。

第3章 結論

本章中依據調查期間所蒐集之事實資料以及綜合分析，總結以下三類之調查發現：「**與可能肇因有關之調查發現**」、「**與風險有關之調查發現**」及「**其他調查發現**」。

與可能肇因有關之調查發現

此類調查發現係屬已經顯示或幾乎可以確定為與本次事故發生有關之重要因素，包括不安全作為、不安全狀況，或與造成本次事故發生息息相關之安全缺失等。

與風險有關之調查發現

此類調查發現係涉及影響飛航安全之潛在風險因素，包括可能間接導致本次事故發生之不安全作為、不安全條件，以及關乎組織與系統性風險之安全缺失，該等因素本身非事故之肇因，但提升了事故發生機率。此外，此類調查發現亦包括與本次事故發生雖無直接關聯，但基於確保未來飛航安全之故，所應指出之安全缺失。

其他調查發現

此類調查發現係屬具有促進飛航安全、解決爭議或澄清待決疑慮之作用者。其中部分調查發現係屬大眾所關切，且常見於國際民航組織（ICAO）事故調查報告之標準格式中，以作為資料分享、安全警示、教育及改善飛航安全目的之用。

3.1 與可能肇因有關之調查發現

1. 事故機自高雄機場起飛前，空調地面連接單向閥可能已經故障無法維持在全關閉位置，使航機加壓艙內與艙外大氣環境連通，航機自巡航高度下降過程中，客艙加壓系統受到當時飛行高度、空調系統進氣量下降及單向閥未關閉的影響，無法建立適當客艙壓力，導致觸發客艙高度過高

警告。（1.6.3, 2.2.1）

3.2 與風險有關之調查發現

1. 本次事故發生前，華信並未評估航空器製造廠於 107 年 2 月發布之單向閥翻新改進資訊信函（RIL-2018-03），更換改良設計的新型單向閥。（1.6.3, 2.2.2）
2. 本次事故發生前，華信 Pre-flight、Transit 及 Daily check 工單無相關使用地面外接冷氣車後，應檢查及確認空調地面連接單向閥在全關閉位置之說明。（1.6.3, 2.2.2）
3. 事故機於飛航空層 130 巡航過程中，因機艙內部空氣自未閉合之單向閥門洩出機外，使客艙高度自約 2,000 呎逐漸上升至約 8,000 呎；飛航組員若曾於航機巡航期間檢查客艙高度之確切數值，應有機會提早發現客艙高度高於正常值。（1.6.3, 1.11.2, 1.18.1.3, 2.3）

3.3 其他調查發現

1. 事故航班飛航組員持有民航局頒發之有效航空人員檢定證與體檢證，飛航資格符合民航局與華信航空要求，訓練與考驗紀錄中查無與本案有關之異常發現。無證據顯示於本次事故中有足以影響飛航組員操作表現之酒精因素。（1.5, 2.1）
2. 事故機之適航與維護符合民航局及華信航空相關規範，本案除空調地面連接單向閥發生故障外，其他航機系統及發動機均無異常。（1.6.2, 1.6.3, 2.1）

第4章 運輸安全改善建議

4.1 改善建議

無。

4.2 已完成之改善措施

華信航空股份有限公司

1. 於「ATR72-600 機型飛航組員訓練手冊」1.2.14 CLIMB-CRUISE 及 2.5.5 EMERGENCY DESCENT 章節中，增列不同飛航空層之參考客艙高度比較表及處置措施對照，以利飛航組員早期發現艙壓異常狀況，而能儘早處置。
2. 將本事件製作為簡報，包含 10,000 ft 檢查重點及客艙高度比較說明，於航務月訊中提供全體飛航組員研讀，以利飛航組員瞭解與學習類似事件的判斷及處理建議。
3. 修訂 ATR72-600 機型之 Pre-flight、Transit 及 Daily check 工單，若當班次飛機有使用外接冷氣車，當外接冷氣車撤離後，機務人員應確認 Air conditioning ground check valve 位置。
4. 本次事件飛機(B-16851)及其餘四架飛機(B-16852～B-16856)已於事件發生後更換為新型 Air conditioning ground check valve，避免 check valve fail in open 情況發生。
5. 於 ATR72-600 機型飛機維護計畫(AMP) 之 A check 項目增訂 Air conditioning ground check valve 檢查工項。
6. 針對品質程序 QP-MP-03「修護手冊、AD 及修護通告管理作業程序」增訂工程師評估 TPS 等修護通告之詳細作業程序，將 TPS 納入工程師須正式評估之修護通告；於 108 年 8 月 30 日完成所有 TPS 之評估，後續每月至 ATR 網站下載新發布之 TPS 進行評估。

附錄 1 法國 ATR(BEA)對調查報告草案之回復意見及運安會決議

ATR Flight Safety
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M : +33 6 28 71 62 36
Email: paul.jouas@atr-aircraft.com

Attention to :
Mr David Romat
Safety Investigator
BEA

Cc Christopher McGregor
Johan Condette
SAFETY
Ref: V-43/20

Blagnac, July 29th, 2020

Dear David,

Please find here below ATR comments to Mandarin Airlines flight AE7931 occurrence report.
The report has captured correctly the technical analysis of the problem.
ATR would suggest to change the event characterization “cabin depressurization” with "Excess cabin altitude" warning since it is more in line with the technical explanation of the occurrence.

Your sincerely,

Paul Jouas
Flight Safety Director
Accident / Incident Investigator

Comment number	Page	Extract of the report	Proposed changes	Rationale
1	3	The aircraft experienced cabin depressurization during descent	The aircraft experienced **an "Excess cabin altitude" warning** during descending	Depressurization refers to sudden lack of pressurization. In this event, it's the engine power reduction coupled with the leak from the duct which generated insufficient flow to maintain the cabin pressure altitude
2	3	After the aircraft landed at Hualien Airport, the maintenance personnel discovered that the spring of the aircraft's air-conditioning ground connection check valve might have broken before the aircraft took off from Kaohsiung Airport, resulting in the check valve not being able to be secured in fully closed position	add the paragraph	could be interesting to add in the report if the air conditioning ground cart has been used before the flight
3	15	The aircraft experienced cabin depressurization during descending.	The aircraft experienced **an "Excess cabin altitude" warning** during descent	same as comments #1

Comment number	Page	Extract of the report	Proposed changes	Rationale
	Page 21	The maximum flight altitude for ATR72-600 aircraft on a normal domestic route is around 14,000	~~The maximum flight altitude for ATR72-600 aircraft~~ On a normal domestic route ~~is around 14,000~~**, the flight altitude of a ATR 72-600 is usually around 14,000 ft in the Mandarin Airlines network.**	Add clarification
	Page 22	The amount of fuel in No. 1 engine was 40kg less than that in No. 2 engine,	The amount of fuel **used** in No. 1 engine was 40kg less than that in No. 2 engine,	Add clarification

4	Page 27 **2.2.1**	**When the occurrence aircraft reached cruising altitude (13,000ft),** the thrust of the engine decreased, and so did the airflow in the air-conditioning system, resulting in the rise of cabin altitude **(after Point A in Figure 2.2-1), but it was maintained at approximately 8,000ft.**	**When the occurrence aircraft reached cruising altitude (13,000ft),** there is a sudden rise of cabin altitude (after Point A in Figure 2.2-1) probably due to the collapse of the air-conditioning distribution tube downstream the valve, which increases the external leakage, not compensated by the air conditioning system. The cabin altitude was finally maintained at approximately 8,000ft.	**The decrease of engine thrust cannot alone explain the increase of the cabin altitude, as the engine thrust in cruise condition is still sufficient to maintain the required regulated pressure and flow supplied to the cabin.**
5	**PAGE 27 2.2.1**	Cabin altitude increased as a result of engine thrust decrease during cruise phase	Cabin altitude increased as a probable result of the collapse of the air-conditioning distribution tube downstream the valve.	The decrease of engine thrust cannot alone explain the increase of the cabin altitude, as the engine thrust in cruise condition is still sufficient to maintain the required regulated pressure and flow supplied to the cabin.

Taiwan Transportation Safety Board

Major Transportation Occurrence Draft Final Report

May 2, 2019

Mandarin Airlines Co., Ltd Flight AE7931

ATR72-212A

National Registration Number B-16851

The aircraft cabin experienced brief loss of pressure during descending

Report Number: TTSB-AOR-20-xx-xxx

Report Date: xx, 2020

According to the Aviation 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.

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

The objective of the TTSB's investigation of major aviation occurrence is to prevent 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.

Executive Summary

On May 2, 2019, Mandarin Airlines passenger flight AE7931, an ATR72-212A aircraft, registration number B-16851, took off from Kaohsiung International Airport for Hualien Airport at 14:32 with 1 captain, 1 first officer, 2 cabin crew members, 1 accompanying crew member, and 48 passengers, a total of 53 persons on board. The aircraft experienced cabin depressurization during descending. After the situation was managed by the flight crew, the aircraft landed at Hualien Airport at 15:28, with no further event. All passengers and crewmembers are safe.

After the aircraft landed at Hualien Airport, the maintenance personnel discovered that the spring of the aircraft's air-conditioning ground connection check valve might have broken before the aircraft took off from Kaohsiung Airport, resulting in the check valve not being able to be secured in fully closed position. Before the occurrence, Mandarin Airlines had not included the technical progress status for the check valve, published by the aircraft manufacturer, in the maintenance notice that required formal assessment. Mandarin Airlines did not refer to the retrofit information letter on the check valve, published by the aircraft manufacturer, for the replacement of the check valve with a modified design. On Mandarin Airlines' inspection checklists, there was no job description about checking and confirming whether the check valve was secured in fully closed position after the ground air-conditioning unit was removed.

After taking off, the engine provided the cabin with sufficient air supply to maintain the cabin altitude during the climb and cruise phase; however, during the descending phase, the engine thrust was reduced to idle, and the cabin altitude climbed to exceed threshold as the air supply decreased. Therefore, the EXCESS CAB ALT warning was triggered. The flight crew donned oxygen masks and declared MAYDAY to the ATC.

According to the Republic of China (ROC) Aviation Occurrence Investigation Act, and the content of Annex 13 to the Convention on International Civil Aviation (ICAO), Taiwan Transportation Safety Board (hereinafter referred to as the "TTSB") was responsible for conducting an independent investigation of the occurrence. The investigation team also included members from: BEA (Bureau d'Enquêtes et d'Analyses, France), CAA Taiwan (Civil Aeronautics Administration, MOTC) and Mandarin Airlines Co., Ltd.

The 'Draft Final Report' of the occurrence investigation was completed in January 2020. In accordance with the procedures, it was reviewed at TTSB's 11th Council Meeting on May 1, 2020 and then sent to relevant organizations and authorities for comments. After comments were collected and integrated, the report was reviewed and approved by TTSB's xxth Council Meeting on XX XX, 2020. The report was published on XX XX, 2020.

There are a total of 6 findings from the draft Final Report but no safety recommendations issued to the related organizations.

Findings as the result of this investigation

Findings Related to Probable Causes

1. The check valve inside the ground air-conditioning connection might have been damaged and could not be secured in fully closed position before the aircraft took off from Kaohsiung Airport. Therefore, the aircraft's pressurization system was connected to the atmosphere outside the cabin. When the aircraft descended from cruise altitude, the EXCESS CAB ALT warning was triggered when the cabin pressurization system failed as a result of the flight altitude, the reduction of air supply from the air-conditioning system, and the check valve could not be secured in fully closed position.

Findings Related to Risk

1. Before the occurrence, Mandarin Airlines had not evaluated the retrofit information letter (RIL-2018-03) about the modified check valve published by the manufacturer on February 2018, and had not replaced the check valve with the modified design.
2. Before the occurrence, on Mandarin Airlines' Pre-flight, Transit or Daily checklist, there was no job description about checking and confirming whether the check valve was secured in fully closed position after the ground air-conditioning unit was removed.
3. When the occurrence flight cruised at FL130, air from the cabin leaked through the check valve not secured in fully closed position and into the atmosphere. Cabin altitude gradually increased from approximately 2,000ft to approximately 8,000ft. If the flight crew had checked the exact figures of cabin altitude during the cruising phase, they could have been aware of the higher-than-normal cabin altitude earlier.

Other Findings

1. The occurrence flight crews were holders of valid airman certification and medical examination issued by Civil Aeronautics Administration, and were qualified by the Civil Aeronautics Administration and Mandarin Airlines. There was no abnormal finding from the training and check records related to this occurrence. There was no evidence indicating the performance of the flight crew was influenced by alcohol effects during the occurrence.

2. The airworthiness and maintenance of the occurrence aircraft were in compliance with the Civil Aeronautics Administration and Mandarin Airlines standards. Except for the malfunction of the ground air-conditioning check valve, there was no abnormal finding on other systems or the engine.

Safety Recommendations

Safety Recommendations

N/A

Improvement Measures Accomplished

Mandarin Airlines Co., Ltd

1. A comparison chart listing the reference cabin altitude at different flight levels and corresponding management measures was updated in Session 1.2.14 CLIMB-CRUISE and Session 2.5.5 EMERGENCY DESCENT of the ATR72-600 Flight Crew Training Manual, to help flight crews identify and manage cabin pressure anomaly at early stage.
2. A briefing report about the occurrence, along with key checking items at 10,000ft and explanation of different cabin altitudes, was included in the monthly newsletter, to help flight crew members study the estimations and recommended procedures for similar occurrences.
3. The Pre-flight, Transit and Daily checklists for aircraft ATR72-600 were revised. If the ground air-conditioning unit is connected to the departing aircraft, the flight crew should confirm the position of the air conditioning ground connection check valve after the unit is removed.
4. The occurrence aircraft (B-16851) and the other four aircrafts (B-16852 - B-16856) have replaced the old check valves with the modified air conditioning ground connection check valves to prevent the occurrence.
5. The air conditioning ground connection check valve was included as an A Check item in the ATR72-600 Aircraft Maintenance Procedures (AMP).
6. Regarding quality procedure QP-MP-03, detailed operational procedures for notice of maintenance, such as engineers to evaluate TPS, etc. was updated in the Maintenance Manual, AD and Operation Procedures for Notice of Maintenance Management. By August 30, 2019, all TPS were evaluated. New released TPS will be downloaded from the ATR website for further

evaluation every month.

Contents

Tables

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Figures

Abbreviation

CVR	Cockpit Voice Recorder
EWD	Engine Warning Display
FCOM	Flight Crew Operating Manual
FCTM	Flight Crew Training Manual
FDR	Flight Data Recorder
ILS	Instrument Landing System
PF	Pilot Flying
PM	Pilot Monitoring
PWC	Pratt & Whitney Canada
QRH	Quick Reference Handbook
RIL	Retrofit Information Letter
SID	Standard Instrument Departure
TPS	Technical Progress Status
UTC	Coordinated Universal Time

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Chapter 1 Factual Information

History of Flight

On May 2, 2019, Mandarin Airlines Co., Ltd (hereinafter referred to as "Mandarin Airlines") passenger flight AE7931, an ATR72-212A[13] aircraft, registration number B-16851, took off from Kaohsiung International Airport (hereinafter referred to as "Kaohsiung Airport") for Hualien Airport at 14:32[14] with 1 captain, 1 first officer, 2 cabin crew members, 1 accompanying crew member, and 48 passengers, a total of 53 persons on board. The aircraft experienced cabin depressurization during descending. After the situation was managed by the flight crew, the aircraft landed at Hualien Airport at 15:28, with no further event. All passengers and crewmembers are safe.

The captain occupied the left seat in the cockpit and was the pilot flying (PF) of the occurrence flight. The first officer occupied the right seat and was the pilot monitoring (PM). The occurrence flight took off from Kaohsiung Airport runway 09 and followed HENGCHUN ONE (NH1) standard instrument departure (SID) procedures before tracking northbound along B591. At 15:04:04, the aircraft was descending from cruising altitude FL130. Approximately 36 nautical miles south-southwest of Hualien Airport on B591 route, the Cockpit Master Caution System was triggered[15] with the CAB ALT warning showing on the Engine Warning Display (EWD). The pressure altitude was 11,890ft with a cabin altitude of 9,398ft at that time. At 15:04:17, while the flight crew was discussing the

[13]ATR72-212A: aircraft model as per type design; ATR72-500: commercial designation for ATR72-212A equipped with the old avionic suite; ATR72-600: commercial designation for ATR72-212A equipped with new avionic suite. The occurrence aircraft is a ATR72-600.

[14] Unless otherwise indicated, all the times in this report refer to Taipei Local Time (UTC+8 hours) in 24-hour clock time, and is based on Flight Data Recorder (FDR) time.

[15] Master caution.

situation, the Cockpit Master Warning System was triggered[16] with EXCESS CAB ALT showing on the EWD. The pressure altitude was 11,629ft and the cabin altitude was 9,833 at this time. The captain declared EMERGENCY DESCENT. After the flight crew performed procedures, such as deploying oxygen masks and goggles, and confirming that the communication between the flight crew was established, the first officer declared MAYDAY to Taipei Approach.

At 15:04:45, the cabin altitude peaked at 10,241ft before it began to descent. At 15:05:19, the EXCESS CAB ALT warning was cancelled when the aircraft descended to a pressure altitude of 10,284ft and the cabin altitude was 9,833ft. At 15:06:03, the flight crew requested approval from Taipei Approach to descend to a pressure altitude of 5,000ft and MAYDAY was canceled. Oxygen masks were removed. The aircraft leveled at a pressure altitude of 5,000ft to confirm that all the procedures were completed.

At 15:14, the flight crew requested radar vectors for the runway 03 instrument landing system (ILS) approach from Taipei Approach. At 15:28, the aircraft landed at Hualien Airport without further event. The flight path of the occurrence aircraft is shown in Figure 1.1-1.

[16] Master warning.

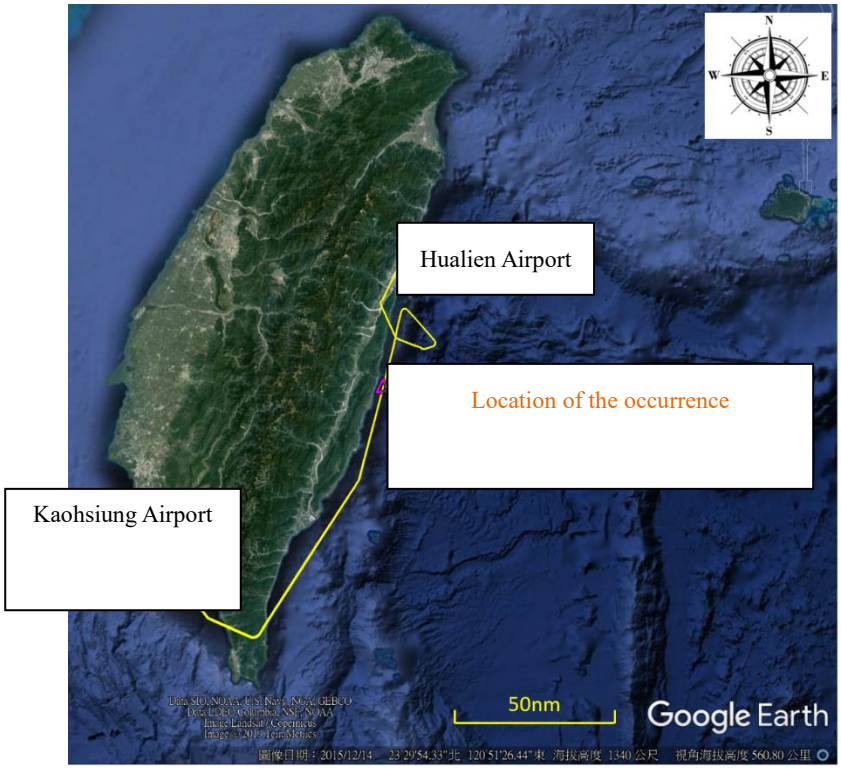

Figure 1.1-1 Flight Path of the Occurrence Aircraft

Injuries to Persons

None

Damage to Aircraft

N/A

Other Damage

N/A

Personnel Information

Flight Crew Background and Experience

Flight crew basic information 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	44	28
Commenced Employment with Mandarin Airlines	April 2017	March 2018
License Type Issued	ATPL-Aeroplane	CPL-Aeroplane
Aircraft Type Rating **Date of Issue** **Date of Expiry**	ATR-72-600, A320 December 7, 2017 December 6, 2022	ATR-72-600 July 26, 2018 July 25, 2023
Medical Certificate Issued **Date of Expiry**	First Class September 30, 2019	First Class July 31, 2019
Total Flying Time[17]	7,587 hours and 11 minutes	666 hours and 56 minutes
Total Flying Time on the Occurrence Aircraft	1,129 hours and 11 minutes	416 hours and 56 minutes
Total Flying Time Last 12 Months	913 hours and 06 minutes	416 hours and 56 minutes
Total Flying Time Last 90 Days	219 hours and 29 minutes	170 hours and 39 minutes
Total Flying Time last 30 Days	77 hours and 03 minutes	63 hours and 53 minutes
Total Flying Time Last 7 Days	22 hours and 12 minutes	14 hours and 27 minutes
Total Flying Time Last 24 Hours	4 hours and 21 minutes	6 hours and 24 minutes
Available Rest Period before Occurrence[18]	38 hours and 03 minutes	16 hours and 09 minutes

Captain

The captain, a Republic of China citizen, was a military pilot. After he retired, he served as captain on the Boeing B777 and the Airbus A320/321/330 fleet in other airlines. He joined Mandarin Airlines in April 2017. After he completed the

[17] Flying time of the table includes the flying time of occurrence till the flight mission is completed.

[18] According to Aircraft Flight Operation Regulations, rest period stands for “a continuous and defined period of time, subsequent to and/or prior to duty, during which flight or cabin crew members are free of all duties”.

transition training for the ATR72-600 flight and passed the airway check, he served as captain on the ATR72-600 fleet. As of the occurrence, he had accumulated a total flight time of 7,587 hours and 11 minutes, which included 1,129 hours and 11 minutes on the ATR72-600 aircraft.

The captain held an Airline Transport Pilot License (ATPL) issued by the Civil Aeronautics Administration (CAA) of the Republic of China with *Aeroplane, Land Multi-Engine, Instrument Rating ATR-72-600 A-320, and privileges for operation of radiotelephone on board an aircraft without limitation.* The captain's English language proficiency was recorded as *ICAO L4 with an expiry date of July 29, 2021.*

The captain’s most recent annual proficiency training before the occurrence was conducted on October 28, 2018. The training covered EXCESS CAB ALT, EMERGENCY DESCENT, etc. The training result was completed. The subsequent annual proficiency check was passed on October 29, 2018. The latest annual aircraft check was passed on January 18, 2019. A review of the captain’s personal training and check records indicated no anomaly. The captain’s first class medical certificate was issued on March 15, 2019 with the limitation that “the holder shall wear corrective lenses”. The captain was wearing corrective lenses during the occurrence. Post-occurrence alcohol testing revealed that the captain's alcohol concentration was 0.

First Officer

The first officer, a Republic of China citizen who completed self-financed pilot training in the United States, obtained the American Commercial Pilot License (CPL) in October 2016. He joined Mandarin Airlines in March 2018. After he completed training for the ATR72-600 aircraft and passed airway check in November 2018, he served as first officer on the ATR72-600 fleet. As of the

occurrence, he had accumulated a total flight time of 666 hours and 56 minutes, which included 250 hours of flight training and 416 hours and 56 minutes on the ATR72-600 aircraft.

The first officer held a Commercial Pilot License (CPL) issued by the Civil Aeronautics Administration (CAA) of the Republic of China with *Aeroplane, Land, Multi-Engine, Instrument Aeroplane ATR-72-600, and privileges for operation of radiotelephone on board an aircraft with the limitation that "ATR-72-600 F/O"*. The captain's English language proficiency was recorded as *ICAO L5 with an expiry date of March 27, 2024.*

The first officer's most recent annual proficiency training before the occurrence was completed on February 14, 2019. The training covered EXCESS CAB ALT, EMERGENCY DESCENT, etc. The training result was completed. The subsequent annual proficiency check was passed on February 15, 2019. A review of the first officer's personal training and check records indicated no anomaly. The first officer's first class medical certificate was issued on July 17, 2018 with the limitation that "the holder shall wear corrective lenses". The first officer was wearing corrective lenses during the occurrence. Post-occurrence alcohol testing revealed that the captain's alcohol concentration was 0.

Aircraft Information

Aircraft and Engine Basic Information

Basic information of the occurrence aircraft as of May 1, 2019 is shown in Table 1.6-1

Table 1.6-1 Aircraft Basic Information Table

Aircraft Basic Information Table	
Nationality	Taiwan, R.O.C
Aircraft Registration Number	B-16851
Aircraft Model	ATR72-212A
Manufacturer	ATR-GIE Avions de Transport Régional
Aircraft Serial Number	1460
Date Manufactured	November 24, 2017
Delivery Date	November 24, 2017
Owner	Avation Taiwan Leasing II Pte. Ltd.
Operator	Mandarin Airlines Co., Ltd.
Number of Certificate of Registration	106-1523
Certificate of Airworthiness	107-11-242
Validity Date of Certificate of Airworthiness	November 15, 2019
Total Flight Time	2,865 hours and 57 minutes
Total Flight Cycles	4,393
Last Check, Date	PA6 Check/ April 22, 2019
Flight Hours since Last Check	56 hours and 50 minutes
Cycles Elapse since Last Check	89

The occurrence aircraft was installed with two PW127M engines manufactured by Pratt & Whitney Canada (“PWC”). Information about the engines as of May 1, 2019 is shown in Table 1.6-2.

Table 1.6-2 Engine Basic Information Table

Engine Basic Information		
Number/Position	No. 1/left	No. 2/right
Manufacturer	PWC	PWC
Model	PW127M	PW127M
Serial Number	PCE-ED1516	PCE-ED1517
Manufacture Date	April 23, 2017	April 24, 2017
Time since Installed	2,865 hours and 57 minutes	2,865 hours and 57 minutes
Cycle since Installed	4,393	4,393

Aircraft Maintenance Information

A review of the last 3 months of the occurrence aircraft's technical log book and deferred maintenance records indicated that there was no anomaly related to the cabin pressurization system. A review of the occurrence aircraft's airworthiness directives and technical bulletins indicated that they were in compliance with applicable standards. No anomaly was detected in the latest PA6 check[19] before the occurrence. A review of the maintenance record of the occurrence aircraft indicated that there were no defects reported under the minimum equipment list, or deferred maintenance item when the aircraft took off from Kaohsiung International Airport.

Cabin Pressurization System and Ground Connection Check Valve

The occurrence aircraft experienced cabin pressure anomaly during the flight. After the aircraft landed at Hualien Airport, ground maintenance personnel examined the aircraft in accordance with the maintenance manual. The ground connection check valve, component number 41125A01, was found failure and could not be secured in the fully closed position (as shown in Figure 1.6-1). The examination also found that the air-conditioning distribution tube downstream the valve was dented. The check valve and the downstream air-conditioning distribution tube were replaced by the maintenance personnel according to the maintenance manual. After testing, the aircraft was in normal condition again.

[19] PA6 Check is the 6th A Check. A Check is performed every 500 flight hours. PA6 Check is performed after 3,000 flight hours.

Figure 1.6-1 Failure Position of the Ground Connection Check Value

The ground connection check valve is located on the right side of the belly of the fuselage, as shown in Figure 1.6-2, equipment number 6352HQ. Its exterior is shown in Figure 1.6-3. When the aircraft is parked on the ground, conditioned air can be supplied to the cockpit and cabin through the check valve from the air-conditioning unit.

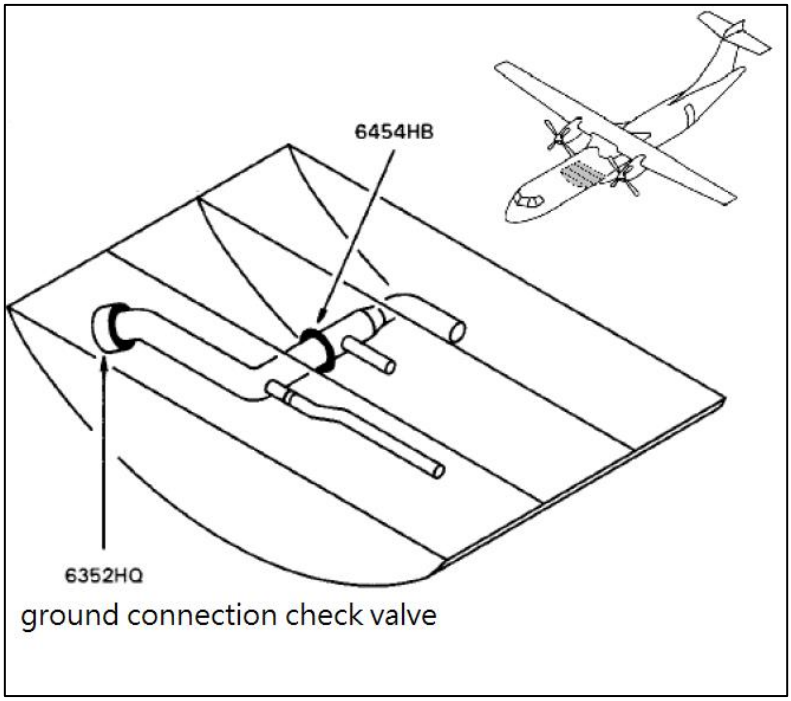

Figure1.6-2 Installation Position of the Ground Connection Check Valve

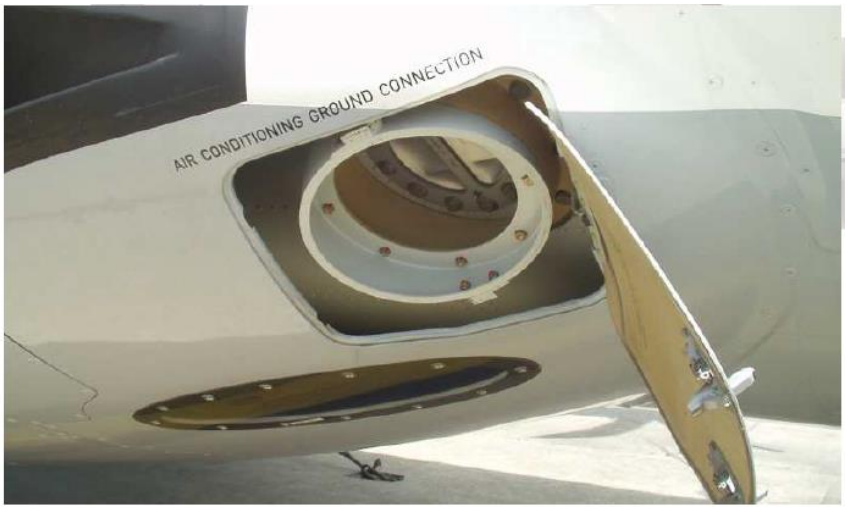

Figure1.6-3 Exterior of the Ground Connection Check Valve

In October 2015, the aircraft manufacturer issued TPS21-22-001 Technical Progress Status (TPS). The TPS mentioned the occurrence of cabin pressure anomaly as a result of the ground connection check valve, component number 41125A01, not secured at a fully closed position due to the failure of valve spring. It also mentioned that when the cabin pressure was compromised, the air-

conditioning distribution tube downstream of the check valve might be damaged due to the difference between pressure inside and outside the cabin. To avoid this occurrence, the aircraft manufacturer recommended checking the check valve position and ensuring it is secured in the fully closed position after every time the air-conditioning unit is moved. The 8th edition released in April 2018 is the latest updated version for this TPS.

In February 2018, the aircraft manufacturer released the RIL-2018-03, a Retrofit Information Letter (RIL) about the check valve, providing the check valve with a modified design (component number 41125A020001). The modified design is fully compatible with the old check valve, component number 41125A01, in the occurrence aircraft, and is interchangeable.

Weather Information

N/A.

Aids to Navigation

N/A

Communication

N/A

Aerodrome

N/A

Flight Recorders

Cockpit Voice Recorder

The aircraft is equipped with a solid-state Cockpit Voice Recorder (CVR)

manufactured by L-3 Aviation Products, component number 2100-1225-22. The CVR is capable of recording 2 hours of high quality audio, with sound sources from the captain's microphone, the first officer's microphone, the broadcasting system microphone and the cockpit area microphone. CVR readout and download was successful and the audio quality was good. CVR consisted of 124 minutes and 14.5 seconds of recording, including the take-off, the cruise, the approach, the occurrence and the landing of the occurrence flight. 12 minutes of information relevant to the occurrence were transcribed by the investigation team.

Flight Data Recorder

The aircraft is equipped with a solid-state Flight Data Recorder (FDR) manufactured by L-3 Aviation Products, component number 2100-4245-00. After the occurrence, the Safety Board analyzed the data in accordance with the data decoding document developed by the aircraft manufacturer. The FDR contained 60 hours, 46 minutes and 37 seconds of data. The total number of recorded parameters was 1,008. All parameters are based on UTC time[20]. Extract of the FDR data related to the occurrence is shown below:

1. At 14:24 Taipei Local Time, FDR started recording.
2. At 14:32 Taipei Local Time, the aircraft took off from Kaohsiung Airport.
3. At 15:02:30 Taipei Local Time, the pressure altitude of the aircraft was 12,950ft and the cabin altitude started to climb from about 8,000ft.
4. At 15:04:17, the master warning was triggered. The pressure altitude of the aircraft was 11,629ft and the cabin altitude was 9,833ft at this time. "Excess cabin altitude" was displayed on the Cockpit Display System.

[20] UTC Time + 8 hours = Taipei Local Time

5. At 15:04:45 Taipei Local Time, the pressure altitude of the aircraft was 11,090ft and the cabin altitude peaked at 10,241ft.

6. At 15:05:19 Taipei Local Time, the pressure altitude of the aircraft was 10,284ft. The EXCESS CAB ALT warning was cancelled when the cabin altitude became 9,833ft.

7. The aircraft landed at Hualien Airport at 15:28:50 Taipei Local Time.

8. At 15:34 Taipei Local Time, FDR stopped recording.

The flight path of the occurrence aircraft is shown in Figure 1.1-1. Figure 1.11-1 depicts the data plot of the recorded parameters for the aircraft.

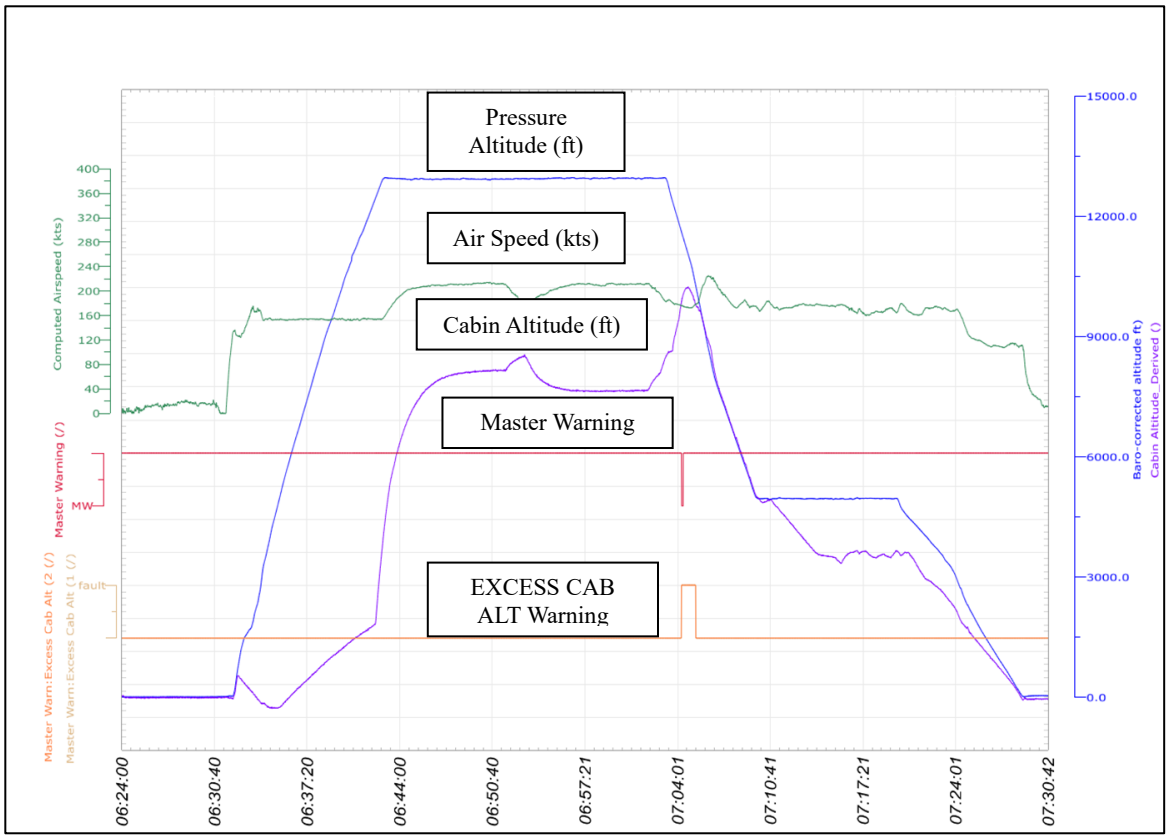

Figure 1.11-1 Flight Data Plot of the Occurrence Aircraft

Wreckage and Impact Information

N/A

Medical and Pathological Information

N/A

Fire

N/A

Survival Aspects

N/A

Tests and Research

N/A

Organizational and Management Information

N/A

Additional Information

Related Content in Flight Operations Manual

Quick Reference Handbook

Contents in the Mandarin Airlines ATR72-600 Quick Reference Handbook[21] that are relevant to the occurrence: CABIN ALTITUDE, EXCESS CAB ALT and EMERGENCY DESCENT. Extracts are shown below:

[21] VERSION REV 0 TR02, valid from January 16, 2019

A21.08	CABIN ALTITUDE
► CABIN ALTITUDE : MONITOR	

EXCESS CAB ALT	A21.10

► CAB PRESS indicator .....CHECK
■ **If rapid decompression**
► AFM - EMERGENCY DESCENT procedure (E99.04) .....APPLY
■ **If cabin altitude > 10 000 ft confirmed**
► CAB PRESS RATE knob .....9 O'CLOCK (MAN POSITION)
► CAB PRESS MODE SEL..... MAN
► CAB PRESS RATE knob ..... DECREASE
■ **If EXCESS CAB ALT persists**
► CREW OXY MASKS..... DON
► CREW COMMUNICATIONS.....ESTABLISH
► OXYGEN PAX SUPPLY..... AS RQRD
► OXYGEN PRESSURE.....CHECK
► DESCENT.....INITIATE AS RQRD
► MAX FL : 100/MEA

E99.04	EMERGENCY DESCENT

► CREW OXY MASKS..... AS RQRD
► CREW COMMUNICATIONS.....AS RQRD
► GOGGLES.....AS RQRD
► DESCENT..... INITIATE
► PL 1+2..... FI
► CL 1+2.....100% OVRD

► OXYGEN PAX SUPPLY..... AS RQRD
► IAS : VMO/MMO (or less if structural damage is suspected)
► SIGNS.....ON
► ATC..... NOTIFY
► MEA..... CHECK

Flight Crew Operating Manual

Contents in the Mandarin Airlines ATR72-600 Flight Crew Operating Manual[22] that are relevant to the occurrence: AUTO PRESS FAULT-Alert, EXCESS CAB ALT-Alert, CABIN ALTITUDE-Alert and AUTO PRESS FAULT. Extracts are shown below:

[22] VERSION REV 0 TR01, valid from January 16, 2019

4.1 AUTO PRESS FAULT-Alert

_27a18dfe-790a-4f8f-b610-1237d44c51d6 2.4
ALL

CONDITION	VISUAL	AURAL
Digital controller failure	- MC light flashing amber - AIR AUTO PRESS amber message on EWD - FAULT amber light on CAB PRESS MOD SEL pb - AUTO PRESS amber message on Cabin SD page	SC

AUTO PRESS FAULT is triggered if the digital control is inoperative.

4.3 EXCESS CAB ALT-Alert

_481be014-82ee-47ff-9fc3-e10042ee6fbe 0.2
ALL

CONDITION	VISUAL	AURAL
Cabin altitude > 10 000 ft (15 000 ft in High Altitude mode)	- MW light flashing red - EXCESS CAB ALT red message on EWD - Red reverse video ALT flashing on Air Cabin SD page	CRC

EXCESS CAB ALT-Alert is triggered if the cabin altitude exceeds 10,000ft (or 15,000ft in high altitude mode).

4.4 CABIN ALTITUDE-Alert

_4c828a69-264b-4dab-a623-a97b9742f79d 0.2
ALL

CONDITION	VISUAL	AURAL
9 500 ft < Cabin altitude < 10 000 ft - OR - 14 000 ft < Cabin altitude < 15 000 ft (in High Altitude mode)	- MC light flashing amber - CAB ALT amber message on EWD	SC

CABIN ALTITUDE-Alert is triggered if the cabin altitude exceeds 9,500ft and is lower than 10,000ft (or if the cabin altitude exceeds 14,000ft and is lower than 15,000ft inhigh altitude mode).

AUTO PRESS FAULT

940538b9-f542-468b-9d3f-202570c694de 3.2
ALL

AUTO PRESS FAULT

► CAB PRESS RATE knob .....9 O'CLOCK (MAN position)
► CAB PRESS MODE SEL ..... MAN
► CAB PRESS RATE knob .....AS RQRD TO ADJUST TARGET CAB ALT

FL	140	170	200	220	240	250
TARGET CAB ALT (ft)	2 500	3 300	4 200	5 200	6 200	6 800

• Before descent
■ If CAB ALT above landing elevation
► CAB PRESS RATE knob .....DECREASE
► CAB ALT RATE..... ADJUST 400 ft/min DN
■ If CAB ALT below landing elevation
► CAB PRESS RATE knob .....INCREASE
► CAB ALT RATE..... ADJUST 1 000 ft/min UP MAX
• When CAB ALT = landing elevation
► CAB PRESS RATE knob .....9 O'CLOCK (MAN position) & MONITOR
• After landing
► CAB PRESS RATE knob ..... MAX INCREASE

AUTO PRESS FAULT is triggered if the flight crew modifies the cabin pressure manually. The procedure demonstrates the target cabin altitude in different flight levels, for example, the target cabin altitude in FL140 is 2,500ft.

Flight Crew Training Manual

In Session 1.2 Standard Operation Procedures of the Mandarin Airlines ATR72-600[23] Flight Crew Training Manual (FCTM), the procedures related to the climb and cruise are shown below:

[23] VERSION REV 3, valid from April 22, 2019

1.2.14 CLIMB – CRUISE

Flight events	PM	PF
PASSING 10,000 or REACHING CRUISE ALTITUDE	▶CALL "TEN THOUSAND" ▶DO ALL SYSTEM PAGES ..... CHECK DURING CLIMB ..... ALL SYSTEMS SCAN PRESSURIZATION ..... MONITOR Check ΔP, CAB ALT, and CAB RATE on SD page. CM1 LANDING LIGHTS ..... OFF WING LIGHTS ..... OFF	▶CALL "CHECK"
1,000FT TO LEVEL OFF	▶ANNOUNCE "ONE THOUSAND"	▶CALL "CHECK"
APPROACHING CRUISE LEVEL/ ALTITUDE	DELTA ISA ..... CHECK FMA ..... X CHECK ▶CALL "CHECK" ▶CALL "CHECK"	FMA ..... MONITOR FL/ALT INTERCEPTION ▶CALL "ALT STAR" ▶CALL "ALT GREEN"
AT CRUISE FL/ ALT	SPEED BUG ..... CHECK ▶CALL "CHECK"	SPEED BUG ..... CHECK ▶CALL "SPEED XXX MAGENTA"
10 KTS BEFORE CRUISE SPEED	▶DO PWR MGT SELECTOR ..... CRZ TQ BUGS ..... CHECK CRUISE PARAMETERS ..... MONITOR Confirm TQ, FF, IAS, and TAS match with ▶CALL "CRUISE POWER SET"	▶CALL "SET CRUISE POWER" CRUISE PARAMETERS ..... MONITOR Confirm TQ, FF, IAS, and TAS match with expected cruise parameters ▶CALL "CHECK"
DURING CRUISE	SYSTEMS ..... MONITOR PERIODICALLY DEST REMAINING FUEL ..... CHECK FMS PREDICTIONS ..... CHECK WPT, DEST ETA, TOD, DEST RAIM, and EFOB	TOP OF DESCENT ..... CHECK REMAINING FUEL & HOLDING TIME .... MONITOR
IF ENCOUNTER TURBULANCE	REFER TO FCOM/ FOM	

The flight crew should monitor the cabin pressurization status when the aircraft climbs above 10,000ft or reaches the cruising altitude. The flight crew should also check the difference between the pressure inside and outside the cabin (△P), the cabin altitude, and the rate of change of the cabin altitude on the system panel. During the cruise phase, the flight crew should monitor different system panels regularly.

Interview Information

Summary of Interview with Captain

The occurrence flight was the captain's 5th flight of the day. He occupied the left seat in the cockpit and was the pilot flying (PF). After taking off from Kaohsiung Airport, the occurrence aircraft followed normal departure procedures. When the aircraft climbed to cruise altitude FL130, the cabin crew reported to the cockpit that the left engine was particularly loud and inquired if there was any problem about it. The flight crew checked the system parameters and found everything to be normal. The accompanying crew member conducted a visual inspection of the area and reported no anomaly.

ATC then approved the occurrence aircraft to descend from FL130, performed an Instrument Landing System (ILS) approach to Hualien Airport runway 03, and informed the aircraft to fly above 5,000ft at waypoint ARBOR. The captain set altitude as final approach fix, at 2,100ft. The LNAV-VNAV mode[24] was enabled, and the aircraft descended at approximately 1,200ft/min. When the aircraft descended to 10,900ft, the amber CAB ALT warning light was triggered on EWD. The first officer checked the readings on the instrument panel that the cabin altitude was 8,900ft. It quickly climbed to 9,900ft and triggered the red EXCESS CAB ALT warning. The altitude of the aircraft at that time was around 10,600ft.

The captain declared EMERGENCY DESCENT immediately. The flight crew performed memory items, including wearing oxygen masks and goggles, and established communication between the crew members. The cabin crew were informed of the emergency descent. MAYDAY was declared to ATC and a descent altitude to 5,000ft was requested. The occurrence aircraft was already descending when the occurrence happened. When the flight crew completed the

[24]LNAV, lateral navigation: it is used to calculate, display and provide a horizontal approach chart or flight path guidance for aircraft regional navigation devices. VNAV, vertical navigation: it is used to calculate, display and provide a vertical approach chart or flight path guidance for aircraft regional navigation devices.

procedures mentioned above, the cautions and warnings on EWD had been cancelled. The cabin altitude returned to normal range. The altitude of the aircraft was below 10,000ft at that time. Oxygen masks in the cabin were considered unnecessary. Considering that the aircraft was near coastal mountains and the cloud-covered ground obstacles were not visible. The captain decided to maintain the original LNAV descent. Therefore, the aircraft was not descending rapidly.

When the aircraft descended to 6,000ft, the captain considered the threat of depressurization had been dismissed, so he asked the first officer to remove his oxygen mask. After confirming it was safe to do so, the captain then took off his oxygen mask. The flight crew then inquired the cabin condition. The aircraft leveled at 5,000ft. After confirming that all the items in the emergency procedures were implemented, the flight crew canceled MAYDAY and requested approach again. The aircraft was radar-vectored by ATC. At 15:28, it landed at Hualien Airport.

On the day of the occurrence, the aircraft condition was normal. Other than scratches on the cabin door and notes related to the radome, there was no deferred maintenance item that would affect the aircraft operation on the technical log book. When the aircraft climbed to 10,000ft during the occurrence flight, the flight crew checked all the instrument panels. All the parameters, including the pressurization system, were displayed in green color, indicating that they were within normal range. However, the exact figures of the cabin altitude and △P were not marked down. No anomaly in the air-conditioning system and the pressurization system were identified before the occurrence. During the flight mission, the two systems were both in automatic mode and were not switched to the manual mode.

The maximum flight altitude for ATR72-600 aircraft on a normal domestic

route is around 14,000ft. Simulator-based training courses on cabin pressure failure simulated the explosive depressurization at 25,000ft altitude and gradual depressurization. In both situations, the emergency descent was performed eventually.

The captain considered himself physically and mentally well during the occurrence. He thought the first officer performed well and demonstrated the ability required to implement procedures, provide advice and maintain effective communication during the occurrence.

Summary of Interview with First Officer

The occurrence flight was the first officer's first flight of the day. He occupied the right seat in the cockpit and was the pilot monitoring (PM). At 14:31, the occurrence flight took off from Kaohsiung Airport and followed HENGCHUN ONE (NH1) standard instrument departure (SID) procedures. When the aircraft climbed to 10,000ft altitude, the cabin chief asked the cockpit if there was anomaly identified in No. 1 engine because the cabin crew heard "sa sa" sounds from the engine, which had never been heard before. The flight crew checked 4 system panels and found that the figures, including engine oil pressure, temperature and revolutions, were all within the normal green band. The only difference between the two engines was fuel consumption, for which No. 1 engine was 370 and No. 2 engine was 365. The amount of fuel in No. 1 engine was 40kg less than that in No. 2 engine, but this was within allowable range. Cabin altitude and △P were both within the normal green band, but exact figures were not marked down. The flight mission continued after the accompanying crew members conducted a visual check of the area and considered it normal.

When the aircraft climbed to cruising altitude FL130, the flight crew requested to ATC to fly directly to waypoint ARBOR, which was approved. ATC

then approved the descent and Instrument Landing System (ILS) approach to Hualien Airport runway 03. The captain set altitude as final approach fix at 2,100ft. LNAV-VNAV mode was enabled.

When the aircraft descended to 10,900ft, master caution was triggered and CAB ALT was displayed on EDW. The first officer checked the instrument panel in accordance with procedures. He found that the cabin altitude was 8,900ft and it quickly climbed to 9,900ft and then 1,600ft. The red EXCESS CAB ALT master warning was triggered as a result. The altitude of the aircraft at this time was approximately 10,600ft, same as the cabin altitude. The cabin pressure was not established.

The captain declared EMERGENCY DESCENT immediately. The flight crew performed memory items. The first officer declared MAYDAY to ATC. The aircraft had been descending before the emergency descent. Therefore, when the flight crew completed donning the oxygen masks and the goggles, established communication between the crew members, and declared MAYDAY to ATC according to procedures, the warning on EWD was cancelled. To avoid being too close to mountains, the flight crew requested the ATC to cancel the permission to approach and requested the descent to altitude 5,000ft. When descended to 5,000ft, the flight crew requested approach again after confirming that all the procedures were completed, and the aircraft condition was stable and functioned normally.

The aircraft condition was normal in the inspection before take-off for the occurrence flight. There was no special note or caution to be taken mentioned in the technical log book. Before the occurrence, there was no anomaly in the air-conditioning system and the pressurization system. During the flight mission, the two systems were both in automatic mode and were not switched to the manual

mode.

The first officer considered himself mentally and physically capable of managing the situation during the occurrence, despite being slightly nervous. He showed no sign of fatigue. The first officer considered the captain's performance to be normal.

Sequence of Events

Sequence of major events of the occurrence is shown in Table 1.18-1.

Table 1.18-1 Sequence of Events

Time	Event	Information Source
14:32	Took off from Kaohsiung Airport	FDR
14:43	Climbed to cruising altitude (FL130)	FDR
15:03	Descended from cruising altitude	FDR
15:04:04	Pressure altitude 11,890ft, cabin altitude 9,398ft. Master caution was triggered with CAB ALT displayed on EWD.	FDR, CVR
15:04:17	Pressure altitude 11,629ft, cabin altitude 9,833ft. Master warning was triggered with EXCESS CAB ALT displayed on EWD.	FDR, CVR
15:04:21	The captain declared EMERGENCY DESCENT. The flight crew donned oxygen masks and goggles, and established communication between the flight crew.	CVR
15:04:40	The first officer declared MAYDAY to Taipei Approach. The aircraft continued the descent in the original navigation mode.	CVR
15:04:45	Maximum cabin altitude reached at 10,241ft before it began to drop.	FDR
15:05:19	Descended to pressure altitude 10,284ft. Cabin altitude at 9,833ft. EXCESS CAB ALT warning was cancelled.	FDR
15:06:03	The flight crew requested to ATC to descend to pressure altitude 5,000ft, MAYDAY was canceled. Oxygen masks were removed. The aircraft leveled at pressure altitude 5,000ft to confirm all procedures were completed.	CVR
15:14	The flight crew requested to ATC radar vectors for the Hualien Airport runway 03 Instrument Landing System (ILS) approach.	CVR
15:28	Landed at Hualien Airport	FDR

Chapter 2 Analysis

2.1 General

The occurrence flight crews were holders of valid airman certification and medical examination issued by Civil Aeronautics Administration (CAA), and were qualified by the Civil Aeronautics Administration (CAA) and Mandarin Airlines. There was no abnormal finding from the training and check records related to this occurrence. There was no evidence indicating the performance of the flight crew was influenced by alcohol effects during the occurrence.

According to the maintenance information of the occurrence aircraft, no defect entry related to the occurrence was made in the aircraft maintenance records and aircraft check records throughout the 3 months before the occurrence. The implementation of airworthiness directives was in compliance with relevant regulations. When the occurrence flight took off from Kaohsiung Airport, there were no defects or inoperative items reported under the minimum equipment list, or deferred maintenance items. In a review of the FDR and CVR records of the occurrence flight, other than the cabin pressurization system anomaly, no other anomaly was identified in the aircraft system or engine.

2.2 Cabin Pressurization System

An aircraft-related analysis was conducted in terms of cause and influence of the cabin pressurization system anomaly, retrofit information provided by the aircraft manufacturer, and improvement measures implemented by Mandarin Airlines.

2.2.1 Analysis of Cabin Pressurization System Anomaly

The occurrence aircraft was connected to ground air-conditioning unit at

Kaohsiung Airport before the occurrence. According to the ground inspection conducted after the occurrence at Hualien Airport, the valve spring applying pressure to the blade of the ground connection check valve was broken, resulting in the valve not being able to be secured in fully closed position. The check valve connected the pressurized cabin from inside to outside. When the aircraft was parked on ground, the ground air-conditioning unit can be connected to the aircraft through the check valve, providing the cockpit and cabin with conditioned air. When the valve functioned normally, conditioned air is supplied one-way from outside to inside the cabin. When the ground air-conditioning tube was removed, the spring applied pressure to the blade, so the valve was automatically spring-forced back to the closed position. When the cabin started to be pressurized, the valve can also be secured in the fully closed position because of the difference of pressure inside and outside the cabin.

According to the post-occurrence inspection, the spring applying pressure to the blade of the valve was broken, resulting in the valve not being able to be secured in fully closed position. When the valve was not fully closed, the pressurized cabin was connected to the atmosphere outside the cabin, and the air leaked out of the pressurized cabin from the check valve. When the engine air supply decreased, the cabin altitude rose and the cabin pressure cannot be maintained as a result.

When the ground connection check valve was not fully closed, the aircraft pressurization system would be influenced by the altitude and the engine air supply. According to the FDR data of the occurrence aircraft, the thrust of the engine during take-off and climbing provided sufficient air to maintain the cabin altitude below 2,000ft (before Point A in Figure 2.2-1). When the occurrence aircraft reached cruising altitude (13,000ft), the thrust of the engine decreased, and so did the airflow in the air-conditioning system, resulting in the rise of cabin

altitude (after Point A in Figure 2.2-1), but it was maintained at approximately 8,000ft. However, when the aircraft descended from cruising altitude (Point B in Figure 2.2-1), the thrust of the engine reduced to idle, therefore the cabin altitude rose rapidly as a result of the decrease in air supply from the air-conditioning system. After approximately 2 minutes and 30 seconds, at 15:04:17, the EXCESS CAB ALT warning was triggered.

To sum up, the check valve inside the ground air-conditioning connection might have been damaged before the occurrence flight took off. Therefore, the aircraft's pressurization system was connected to the atmosphere outside the cabin. As the aircraft descended from cruise altitude, the EXCESS CAB ALT warning was triggered when the cabin pressurization system failed as a result of the altitude, the reduction of cabin air inflow, and the check valve was not secured in closed position.

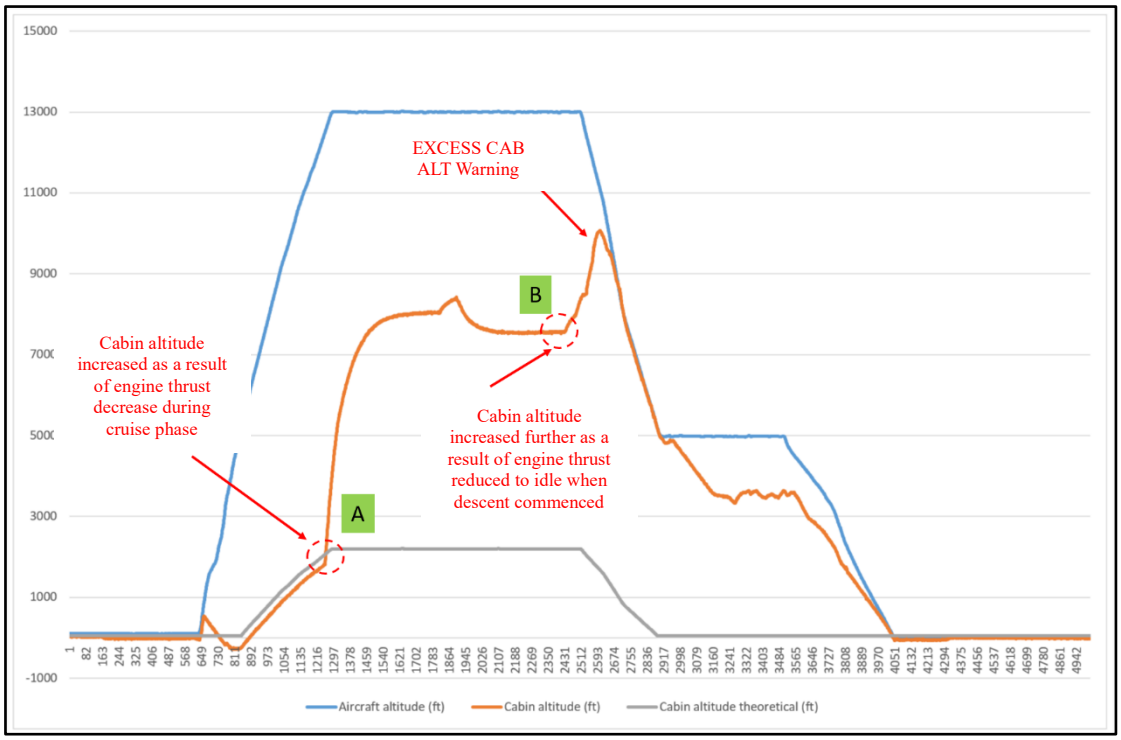

Figure 2.2-1 Cabin Altitude and Relevant Information Plot

2.2.2 Retrofit Information on Ground Connection Check Value

TPS21-22-001 Technical Progress Status (TPS) released by the aircraft manufacturer mentioned the occurrence of cabin pressure anomaly as a result of the ground connection check valve (component number 41125A01), not secured at fully closed position due to an inoperative spring. To avoid the occurrence, the aircraft manufacturer recommended inspecting the check valve position and ensuring it is secured in the fully closed position, after every time the ground air-conditioning unit is moved. Before the occurrence, there was no job description about the ground connection check valve in Mandarin Airlines' daily check list of the occurrence aircraft.

In February 2018, the aircraft manufacturer released a retrofit information letter (RIL-2018-03) about the modified check valve (component number 41125A020001). According to RIL-2018-03, the modified check valve improved the component reliability and can avoid cabin depressurization as a result of an inoperative spring of the valve. The modification features the following:

- Two devices have been added to secure the valve blades in a stable position
- A middle dead point has been added to eliminate vibration
- A teflon-coated gasket between the shaft and the spring

The modified check valve is interchangeable with the original one (component number 41125A01). The exterior of the two check valves are shown in Figure 2.2-2.

	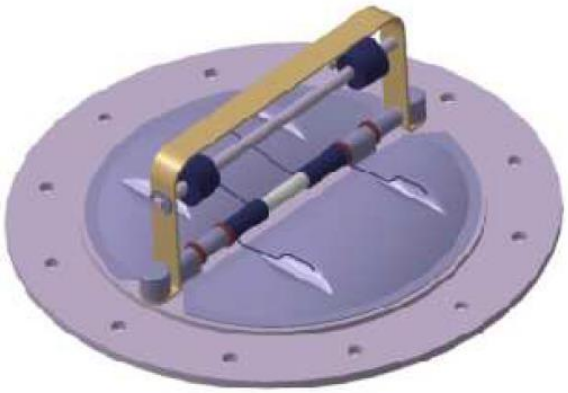
Original component number 41125A01	Modified component number 41125A020001

Figure 2.2-2 Original Check Valve (Left) and Modified Check Valve (Right)

After the occurrence, Mandarin Airlines implemented the following improvement measures based on the aircraft manufacturer's recommendation on check operation and product retrofit information mentioned above.

- *The replacement of the air conditioning ground check valve for the occurrence aircraft (B-16851) was completed after the occurrence. The replacement of the new check valve for the other four ATR72 aircrafts (B-16852-B-16856) were implemented on May 14 and May 15, 2019. ATR72 aircrafts (B-16857, B-16858) delivered this year were manufactured with the new check valve (standard modification).*

- *According to the TPS21-22-001 recommendation, the Flight Crew Department revised the Pre-flight, Transit and Daily Checklist on May 3, 2019, with an additional note: if the ground air-conditioning unit is connected to a departing aircraft, the flight crew should confirm that the air conditioning ground check valve is secured at fully closed position after the unit is removed.*

- *In addition to performing checks based on MPD/AMP C check ZL192-GVI-100000-1, the visual check of the air conditioning connection check valve was updated as a check item every 500FH in the AMP. (Item No. 212251-99-1).*

Regarding the occurrence of the cabin pressure anomaly as a result of the inoperative air conditioning ground connection check valve, the aircraft manufacturer had provided relevant retrofit information. After evaluating the information, Mandarin Airlines implemented the corresponding improvement measures. Along with updating the visual check of the ground connection check valve as a check item in the daily check and in the check every 500FH, the replacement of the modified check valve was completed for all the aircrafts in the fleet. Therefore, TTSB proposed no further recommendations regarding the inoperative air conditioning ground connection check valve that may result in cabin pressure anomaly.

2.3 Cabin Altitude Monitor and Anomaly Management

According to the effective Mandarin Airlines ATR72-600 Aircraft Flight Crew Training Manual at the occurrence, when the aircraft climbed to 10,000ft and/or during the cruise phase, the flight crew should monitor all the cockpit system panels, including the difference between the pressure inside and outside the cabin (△P), the cabin altitude and the rate of change of the cabin altitude.

CVR transcript and interview records revealed that when the aircraft climbed to 10,000ft pressure altitude, the flight crew monitored all the cockpit system panels as described above. At that time, all the figures, including those of the air-conditioning system and the pressurization system, were in green or within the green band. The flight crew therefore assumed all the systems were functioning properly and did not pay special attention to the exact cabin altitude.

According to the Mandarin Airlines ATR72-600 Aircraft Flight Crew Training Manual, the target cabin altitude at FL140 is 2,500ft. Therefore, under normal circumstances, the cabin altitude of the occurrence flight at FL130 should be slightly lower than 2,500ft. FDR data revealed that when the occurrence flight cruised at FL130, the cabin altitude gradually increased from approximately 2,000ft to approximately 8,000ft before the descent of the aircraft. If the flight crew had checked the exact altitude during the cruise phase, they could have noticed the higher-than-normal cabin altitude earlier.

When the flight crew commenced the descent, the engine thrust was reduced to idle. The air supply from the air-conditioning system decreased further. The cabin altitude increased further and triggered the CAB ALT caution. At that time, the flight crew were aware of the anomaly. When they checked the cabin altitude, it had reached 9,900ft and the EXCESS CAB ALT warning was triggered immediately. Considering the situation as rapid depressurization, the flight crew initiated emergency descent procedures.

After the occurrence, Mandarin Airlines updated the Flight Crew Training Manual of the occurrence aircraft. A comparison chart listing the reference cabin altitude at different flight levels and corresponding management measures was added in Session 1.2.14 CLIMB-CRUISE and Session 2.5.5 EMERGENCY DESCENT, to help the flight crew identify and manage the cabin pressure anomaly at an early stage. Mandarin Airlines also included a briefing report about the occurrence in the monthly newsletter, for all flight crew members to study. Therefore, TTSB proposed no further recommendations regarding aircraft operation.

Chapter 3 Conclusion

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

The Findings Related to Risks 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 check valve inside the ground air-conditioning connection might have been damaged and could not be secured in fully closed position before the aircraft took off from Kaohsiung Airport. Therefore, the aircraft's pressurization system was connected to the atmosphere outside the cabin. As the aircraft descended from cruise altitude, the cabin pressure warning was triggered when the cabin pressurization system failed as a result of the flight altitude, the reduction of cabin air inflow, and the check valve not being able to be secured in fully closed position. (1.6.3, 2.2.1)

3.2 Findings Related to Risk

1. Before the occurrence, Mandarin Airlines had not evaluated the retrofit information letter (RIL-2018-03) about the modified check valve published by the manufacturer on February 2018, and had not replaced the check valve with the modified design. (1.6.3, 2.2.2)
2. Before the occurrence, on Mandarin Airlines' Pre-flight, Transit or Daily checklist, there was no job description about checking and confirming whether the check valve was secured in fully closed position after the ground air-conditioning unit was removed. (1.6.3, 2.2.2)
3. When the occurrence flight cruised at FL130, air from the cabin leaked through the check valve not secured in fully closed position and into the atmosphere. The cabin altitude gradually increased from approximately 2,000ft to approximately 8,000ft. If the flight crew had checked the exact figures of cabin altitude during the cruising phase, they could have been aware of the higher-than-normal cabin altitude earlier. (1.6.3, 1.11.2, 1.18.1.3, 2.3)

3.3 Other Findings

1. The occurrence flight crews were holders of valid airman certification and medical examination issued by Civil Aeronautics Administration, and were qualified by the Civil Aeronautics Administration and Mandarin Airlines. There was no abnormal finding from the training and check records related to this occurrence. There was no evidence indicating the performance of the flight crew was influenced by alcohol effects during the occurrence. (1.5, 2.1)
2. The airworthiness and maintenance of the occurrence flight were in compliance with the Civil Aeronautics Administration and Mandarin Airlines standards. Except for the malfunction of the ground air-conditioning check valve, there was no abnormal finding on other systems or engine. (1.6.2, 1.6.3, 2.1)

Chapter 4 Safety Recommendations

4.1 Safety Recommendations

No.

4.2 Improvement Measures Accomplished

Mandarin Airlines Co., Ltd.

1. A comparison chart listing the reference cabin altitude at different flight levels and corresponding management measures was updated in Session 1.2.14 CLIMB-CRUISE and Session 2.5.5 EMERGENCY DESCENT of the ATR72-600 Flight Crew Training Manual, to help flight crews identify and manage cabin pressure anomaly at early stage.
2. A briefing report about the occurrence, along with key checking items at 10,000ft and explanation of different cabin altitudes was included in the monthly newsletter, to help flight crew members study the estimations and recommended procedures for similar occurrences.
3. The Pre-flight, Transit and Daily checklists for aircraft ATR72-600 were revised. If the ground air-conditioning unit is connected to the departing aircraft, the flight crew should confirm the position of the air conditioning ground connection check valve after the unit is removed.
4. The occurrence aircraft (B-16851) and the other four aircrafts (B-116852 B-16856) have replaced the old check valves with the modified air conditioning ground connection check valves to prevent the occurrence.
5. The air conditioning ground connection check valve was included as an A Check item in the ATR72-600 Aircraft Maintenance Procedures (AMP).
6. Regarding quality procedure QP-MP-03, detailed operational procedures for notice of maintenance, such as engineers to evaluate TPS, etc. was updated

in the Maintenance Manual, AD and Operation Procedures for Notice of Maintenance Management. By August 30, 2019, all TPS were evaluated. New released TPS will be downloaded from the ATR website for further evaluation every month.

Report chapter	Extract of draft report	ATR (BEA) proposed changes	TTSB actions
Executive summary	民國 108 年 5 月 2 日，華信航空股份有限公司一架 ATR72-212A 型客機，國籍標誌及登記號碼 B-16851，航班編號 AE7931，於 1432 時自高雄國際機場起飛，執行飛往花蓮機場之飛航任務，機上載有正、副駕駛員各 1 人、客艙組員 2 人、隨機機務 1 人、乘客 48 人，共計 53 人。該機於下降過程中發生客艙失壓情形，經飛航組員處置後，於 1528 時降落花蓮機場，人機均安。	The aircraft experienced an "Excess cabin altitude" warning during descending	Accept related report change in Chinese: …。該機於下降過程中「客艙高度過高」警告作動，…
Executive summary	事故機於花蓮機場落地後，維修人員檢查發現該機空調地面連接單向閥自高雄機場起飛前可能已因閥門彈簧斷裂，使單向閥閥門無法維持在全關閉位置。	add the paragraph	Not accept The related contents was already included in 2.2.1.
1.1	民國 108 年 5 月 2 日，華信航空股份有限公司（以下簡稱華信航空）一架 ATR72-212A1 型客機，國籍標誌及登記號碼 B-16851，航班編號 AE7931，於 1432 時 2 自高雄國際機場（以下簡稱高雄機場）起飛，執行飛往花蓮機場之飛航任務，機上載有正、副駕駛員各 1 人、客艙組員 2 人、隨機機務 1 人、乘客 48 人，共計 53 人。該機於下降過程中發生客艙失壓情形，經飛航組員處置後，於 1528 時降落花蓮機場，人機均安。	The aircraft experienced an "Excess cabin altitude" warning during descending	Accept related report change in Chinese: …。該機於下降過程中「客艙高度過高」警告作動，…

1.18.2.1	ATR72-600 型機平日用於飛航國內航線時，最大飛行高度約為 1 萬 4,000 呎。	~~The maximum flight altitude for ATR72-600 aircraft On a normal domestic route is around 14,000,~~the flight altitude of a ATR 72-600 is usually around 14,000 ft in the Mandarin Airlines network.	Accept related report change in Chinese: 華信 ATR72-600 型機平日用於飛航國內航線時，最大巡航高度約為 1 萬 4,000 呎。
1.18.2.2	1 號油箱之油量較 2 號油箱少了 40 公斤，…	The amount of fuel used in No. 1 engine was 40kg less than that in No. 2 engine,	Not accept The sentence was extracted from FO's interview notes, the related draft corresponded to his statement.
2.2.1	事故機到達巡航高度（13,000 呎）後，發動機推力下降同時使空調系統進氣量下降，導致航機客艙高度上升（圖 2.2-1A 點以 後），惟仍控制在約 8,000 呎；	When the occurrence aircraft reached cruising altitude (13,000ft), there is a sudden rise of cabin altitude (after Point A in Figure 2.2-1) probably due to the collapse of the air-conditioning distribution tube downstream the valve, which increases the external leakage, not compensated by the air conditioning system. The cabin altitude was finally maintained at approximately 8,000ft.	Not accept The air-conditioning distribution tube downstream the valve, though distorted, did not break, therefore, the external leakage would not be increased. The draft report will not be changed.

圖 2.2-1	巡航階段推力下降客艙高度升高	Cabin altitude increased as a probable result of the collapse of the air-conditioning distribution tube downstream the valve.	Not accept The air-conditioning distribution tube downstream the valve, though distorted, did not break, therefore, the external leakage would not be increased. The draft report will not be changed.