Loss of control during taxi and ground collision involving SAAB 340B, A3-PUA

Fua'amotu International Airport, Tonga, on 8 December 2023

Chief Investigator - Tonga Civil Aviation Office Aviation Safety Report

Aviation Occurrence Investigation

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Investigation summary

What happened

On 8 December 2023, a Lulutai Airlines Limited SAAB 340B (SAAB), registered A3-PUA was conducting a scheduled regional passenger service from Fua’amotu International Airport, Tongatapu, to Lupepau’u Airport, Vava’u. On descent into Vava’u, the flight crew identified an issue with the aircraft’s main hydraulic system not indicating pressure to some systems, and no indication of hydraulic fluid in the tank. The crew elected to return to Fua’amotu and were able to lower the aircraft’s landing gear with the auxiliary hydraulic system. After a successful landing, the aircraft lost brake pressure during the taxi to the domestic terminal, exiting the taxiway and impacting a disused refuelling bund, collapsing the right landing gear leg. The 3 crew and 35 passengers were able to evacuate the aircraft without injury.

What the investigation found

The investigation found that a tripped circuit breaker had removed power from the hydraulic quantity indicator, as well as the main hydraulic accumulator pressure and inboard wheel brakes accumulator pressure indicators. It could not be determined when the circuit breaker tripped on the flight, however, this was not detected by the first officer while performing the initial hydraulic system troubleshooting, most likely due to an expectancy error. The flight crew subsequently misidentified the indication issue as a hydraulic leak, and commenced the abnormal checklist for hydraulic fluid loss, which included turning off the hydraulic pump (the hydraulic system was operating normally until that time). As a result, no hydraulic pressure was automatically provided to the hydraulic system. While the crew reviewed sections of the hydraulic loss abnormal checklist during the emergency, they did not read all parts of the checklist. Further, the flight crew only had a basic understanding of the aircraft's hydraulic system. As a result, the flight crew had an incomplete appreciation of the limitations of the inoperative hydraulics system.

During the return to Fua'amotu, the flight crew made the decision to stop on the runway after landing in accordance with the abnormal checklist. During the approach, and after landing, the crew discussed the possibility of taxiing, and after the captain recognised that they had brake pressure remaining after landing, and without a readily available aircraft tug, continued to taxi to the terminal. However, when close to the terminal, the aircraft lost wheel braking and directional control due to the depletion of hydraulic pressure, resulting in the aircraft veering off the apron and the collision.

The investigation also identified that the flight data recorder, while being supplied with power, was not recording flight data. This was due to a flight data acquisition unit having an internal fault which resulted in its circuit breaker tripping. The fault identified by the tripped circuit breaker, went unrectified as it was misdiagnosed as an issue with the aircraft's high frequency radio system, and had been isolated with a locking collar to prevent resetting likely 8 days before the accident.

Examination of the cockpit voice recorder identified that the underwater locator beacon and its mounting bracket had been removed at least 5 months before the accident.

Additionally, the missing underwater locator beacon and collared data acquisition unit circuit breaker were not recorded in the aircraft’s technical log, or appropriately actioned when identified.

Although two maintenance defects were identified during the investigation were not recorded in the aircraft's technical logbook, or appropriately actioned when identified, there was considerable evidence to indicate that defect rectification was regularly being conducted and recorded correctly.

While the chief executive officer was seated on the flight deck in an observation seat, there was no evidence to indicate that they influenced the crew's decision making during the accident flight.

What has been done as a result

Lulutai Airlines identified several key observations and potential corrective actions that could be drawn from the available information provided in the preliminary report for this investigation. These included reviewing maintenance practices around hydraulic and CVR systems, and integrating lessons learnt from the accident into their procedures.

Safety message

This accident highlights the necessity for accurate assessment of system functionality following an in-flight system issue and the need to follow and action aircraft checklists in their entirety. Vigilance when assessing aircraft system status is vital to minimise opportunities for error and avoid relying on potentially misleading indicators. It has been well established that the importance of training, following standard procedures, and effective communications are crucial to aviation safety.

Defect recording and reporting by operational and maintenance crews is paramount to providing a means of guided troubleshooting and a path to defect resolution without issues being overlooked or remaining unserviceable. This will ensure continued airworthiness of the aircraft and its systems.

Contents

The occurrence

History of the flight

Morning scheduled passenger service

On 8 December 2023, a Lulutai Airlines Limited SAAB 340B, registered A3-PUA (Figure 1), conducted a scheduled regional passenger service from Fua'amotu International Airport, Tongatapu, to Lupepau'u Airport, Vava'u, and return. The flights were uneventful, landing back at Fua'amotu at about 1130 Tonga Standard Time.[1]

After arrival, the same flight crew prepared the aircraft for another scheduled domestic air service to Lupepau'u Airport, operating as Tonga 14. On board were 3 crew, consisting of a captain, first officer (FO) and a flight attendant (FA), and 35 passengers. The company's chief executive officer (CEO), who had planned to travel on that flight, requested to travel in the observation seat on the flight deck to observe the operation. The captain for that flight had the authorisation to allow company staff to travel in the observation seat and permitted the CEO to occupy that seat for this flight.

The flight crew conducted the appropriate preparatory checklists, and departed Fua'amotu Airport at about 1226 with the FO as pilot flying. During the flight, the flight crew conducted their normal checklist items and communicated with air traffic control (ATC). They also interacted with light general conversation involving the CEO, outside of their flight crew duties.

Figure 1: SAAB 340B A3-PUA

Source: Lulutai Airlines Limited

[1] Tonga Standard Time (TST): Coordinated Universal Time (UTC) + 13 hours.

Hydraulic system issue

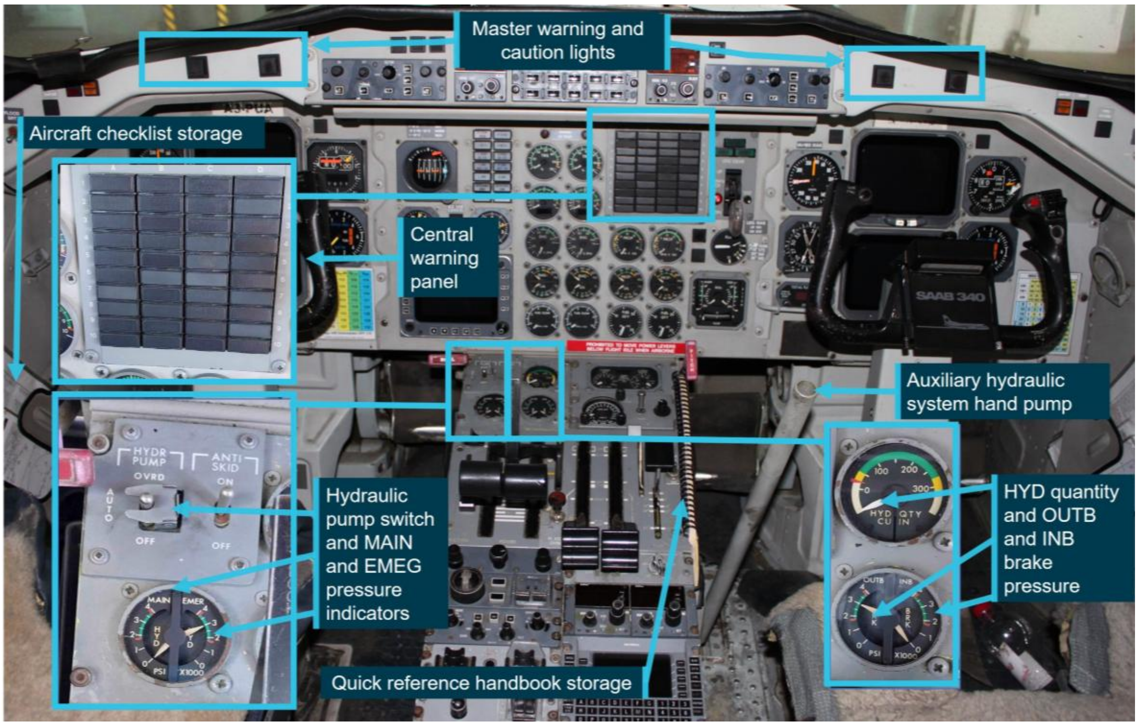
At about 1306, and about 35 NM from Lupepau'u Airport, the flight crew commenced their descent from 11,000 ft. As the aircraft descended through about 8,000 ft, the FA advised that the cabin was secure for landing, and the flight crew commenced the landing checklist. While verifying the main hydraulic system quantity as part of the checklist, the FO identified that the main hydraulic system quantity was indicating empty.

A download of the cockpit voice recorder by the Australian Transport Safety Bureau (ATSB) helped develop the following timeline after identification of the in-flight hydraulic system issue.

The crew commenced troubleshooting and selected the hydraulic pump switch to override, however there was no change in the instrument indications, so they returned the switch to the automatic position. The crew confirmed the following indications on the hydraulic panel (Figure 2):

- hydraulic quantity – 0 in^3
- main hydraulic accumulator pressure – 0 psi
- auxiliary hydraulic accumulator pressure – 3,000 psi
- inboard (INB) wheel brake accumulator pressure – 0 psi
- outboard (OUTB) wheel brake accumulator pressure – 3,000 psi.

Figure 2: Inset hydraulic panel photos taken in-flight showing the observed indications



Source: Supplied by TCAO, annotated by the ATSB accredited representative to Tonga Chief Investigator

The captain then began checking that the circuit breakers[2] had not tripped and asked the FO to check the circuit breakers on their side. After a brief moment the FO identified that these were 'all good'. The captain observed that no warning or caution lights were illuminated on the master caution or central warning panel (CWP), which the captain thought was unusual, so they confirmed the CWP lights worked correctly with its test button, but the FO believed the issue was due to no hydraulic fluid. The captain then commenced checklist 'Abnormal Checklist – HYDR light on' (see Appendix A: Lulutai Airlines Abnormal checklist - HYDR light on).

Shortly after, the FO suggested returning to Fua'amotu Airport, however the captain said to hold course while they continued troubleshooting, as everything else appeared normal apart from the 3 indicators, and rechecked the operation of the CWP warning lights, which illuminated when tested. The FO again noted the problem was likely the hydraulic quantity. The captain then restated that the circuit breakers were in.

About 3 minutes after identifying the hydraulic issue, with no illumination of the CWP warning light, the crew considered that there was a potential hydraulic leak and then commenced the 'Abnormal Checklist – HYDRAULIC FLUID LOSS' (see Appendix B: Lulutai Airlines Abnormal checklist - hydraulic fluid loss). As the first item of the checklist, the hydraulic pump was selected to 'OFF' and then the captain read aloud a note in the checklist, 'Note: a large number of hand pump strokes with gradual increase in resistance is required to obtain desired pressure', and noted reducing airspeed to 200 kt.

The crew again discussed returning to Fua'amotu Airport as there were company maintenance services available there, and that the airport offered a longer runway. As a result of the discussion, the crew notified ATC that they were returning to Fua'amotu Airport. ATC acknowledged this, clearing them to return at 6,000 ft, and requested the nature of their return (Figure 3). The crew also explained to the CEO what they were planning, and about the issue they were dealing with.

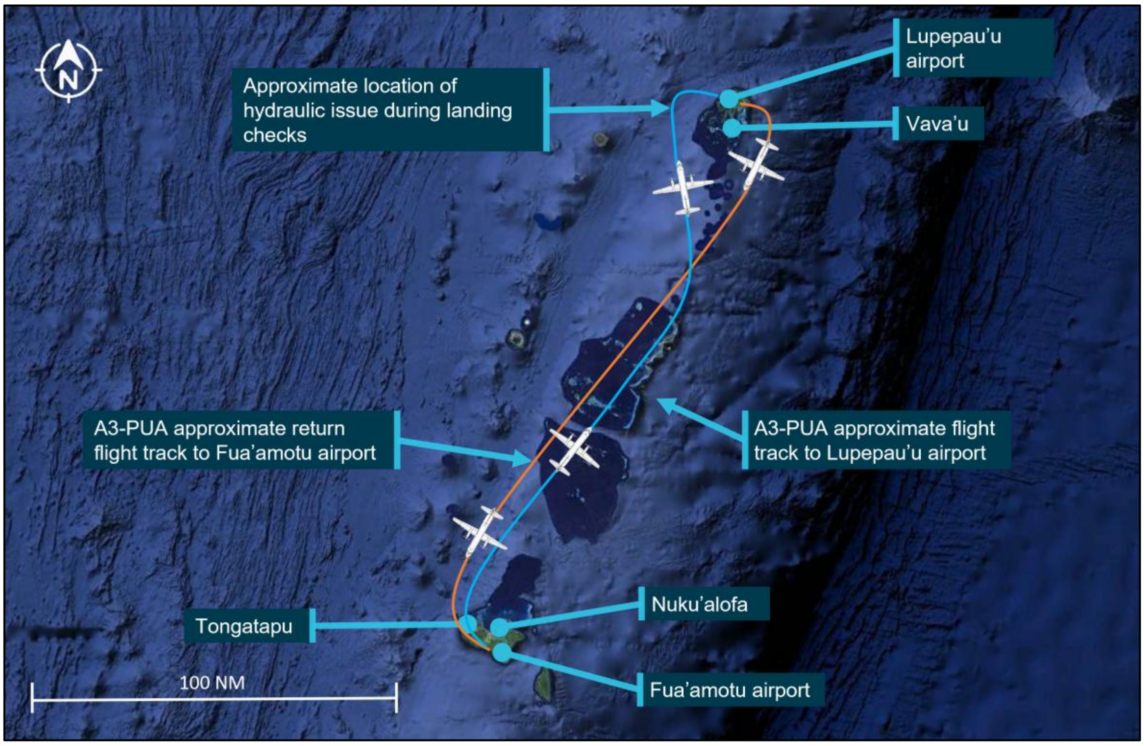
Further discussion was had around the instrument indications, with the captain explaining that there should be a light on the CWP to highlight the system problem, and the FO believing it was due to no hydraulic quantity. The captain remarked that the electrical system appeared normal.

The crew continued to refer to the checklist, with the captain reading portions of the notes aloud. These included the requirement for a large number of hand pumps for the auxiliary pump to maintain hydraulic pressure, and that the normal action with a faulty hydraulic pump was to tow the aircraft on the ground.

Shortly after, the crew requested to return at 10,000 ft, however ATC cleared them at 8,000 ft due to conflicting traffic. The captain made an announcement to the passengers explaining that they were returning to Fua'amotu Airport and shortly after briefed the FA regarding the reason for the return. They then commenced reviewing the abnormal checklist again, further noting that they did not have any warning lights.

2 A circuit breaker is an electrical safety device. It is designed to protect an electrical circuit from damage caused by excess current at a pre-determined level by interrupting the electrical circuit (tripped or pulled). Each crew member has a circuit breaker panel located adjacent to their respective seats, in clear view for that individual.

Figure 3: Approximate flight path including the return to Fua'amotu



SAAB model not to scale
Source: Google Earth, annotated by the ATSB accredited representative to Tonga Chief Investigator

The crew then discussed conducting a flapless landing and discussed the abnormal checklist items with emphasis on the hydraulic pressure being available for the outboard brakes and the manual landing gear extension. They also discussed the ability to 'blow' down the undercarriage with the emergency system if required, with the captain remarking that they still believed there was an electrical fault.

The captain then commenced duties as pilot flying, as the FO would be required to operate the pump handle for the auxiliary hydraulic system to increase its pressure for the landing gear extension. The crew further discussed conducting a flapless landing and the appropriate approach speed for the landing.

The captain again noted that there should have been a hydraulic warning light on the CWP accompanying the indicators issue, and again suspected it was an indicator or wiring fault. The FO took photographs of the indicators and CWP to provide to their engineering department on return.

The FO discussed the towing option if the aircraft was difficult to taxi. They read aloud one of the notes: 'normal action is to park the aircraft and tow on the ground, it is challenging to taxi on ground with hand pump'. The captain agreed that they would park and get engineering to tow the aircraft, and that they would call the company to organise engineering when they got closer.

ATC directed the crew for an approach on runway 11, and the crew advised ATC that they were returning due to a hydraulic issue. At about 1331, ATC then requested if the crew required a local standby,[3] or full emergency response,[4] and the crew responded 'local'. ATC notified the Rescue and Fire Service (RFS) of a local standby for A3-PUA. RFS treated it as a full emergency response, and notified key stakeholders, including the hospital and His Majesty's Armed Forces (HMAF), who went on stand-by to assist as required.

The flight crew decided that they would lower the landing gear when 50 NM from Fua'amotu and discussed leaving the passengers on board during towing or get a bus. The crew then tried contacting their company to organise towing, however they did not receive a response.

Approach, landing, and taxi

At 54 NM from Fua'amotu Airport, the crew carried out their approach checks and commenced their descent. They discussed use of the auxiliary hydraulic pump, selected it to 'FLAPS LDG GR', then selected the landing gear lever to 'down'. The landing gear began to transition and nosewheel locked down, followed by the right landing gear leg. The FO then pumped the auxiliary hydraulic system pump about 8-10 times, and the left landing gear leg locked down. The landing checklist was then carried out, followed by them receiving a call from their company, requesting the nature of their return to Fua'amotu. The crew explained the situation and requested engineering support and towing. The company said that the engineer had just left the office, indicating that it may be a while before they would arrive. The FO asked whether they would attempt taxiing the aircraft after landing, and the captain suggested it may be possible with the rudder pedals.

At about 1356, ATC cleared the aircraft to land. At about 600 ft on final approach, the FO asked the captain if they wanted to try selecting flap, and the captain agreed, however the flaps did not move. The captain called for flaps to be deselected, and the FO confirmed flapless landing. About a minute later, the aircraft landed safely and slowed down with reverse thrust and wheel brakes.

The FO asked the captain if they would try taxiing, and the captain said they would see. The crew were able to taxi the aircraft using the rudder to steer and used available wheel brakes for speed control. They taxied along runway 35, and then taxiway 'Alpha', onto the domestic terminal apron. As they approached the terminal, and before commencing their final right turn, the captain identified that they had no brakes, and the aircraft departed the taxiway (Figure 4). The FO shut down the engines with the condition levers shortly before the right landing gear leg impacted a disused concrete bund[5] area, that was part of a previous refuelling installation, at about 1400. The aircraft veered to the right, and the right landing gear collapsed.

The captain made an evacuation call on the passenger announcement system, and as the main exit on the forward left side of the cabin was unable to be used due to the

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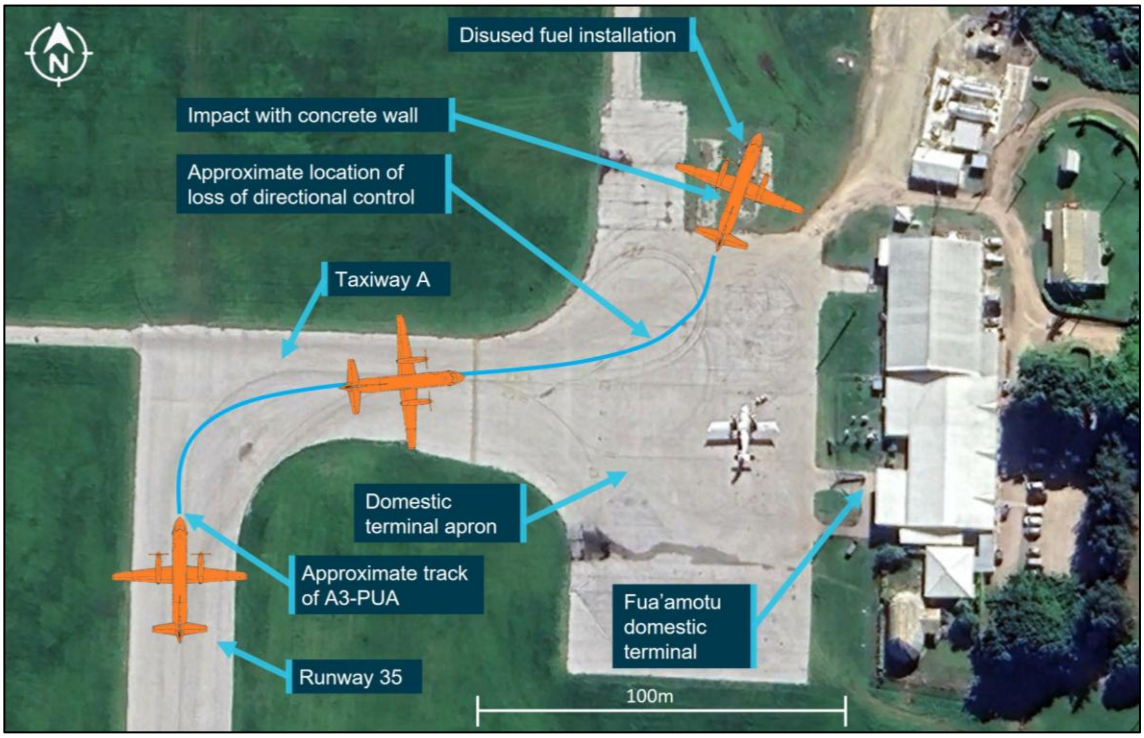
[3] Local Standby Phase: brings aerodrome based emergency services to a state of readiness. Off-aerodrome emergency services may be notified.

[4] Full emergency Phase: brings all emergency response facilities, on and off the aerodrome, to a rendezvous point on the aerodrome. It will alert the hospital to prepare for possible reception of injured.

[5] Spill containment area, commonly used around and under fuel storage tanks to capture unanticipated leaks.

aircraft leaning to the right, nominated the forward right emergency exit to be used. The FA opened the emergency exit and commenced evacuating passengers. Fire services, who were following the aircraft from the runway back to the domestic terminal, and HMAF personnel who were on stand-by to assist, were able to help passengers and crew to exit the aircraft. There were no reported injuries.

Figure 4: Approximate taxi path and point of loss of control



SAAB model not to scale
Source: Google Earth, annotated by the ATSB accredited representative to Tonga Chief Investigator

Context

Personnel information

Captain

The captain held an Air Transport Pilot Licence (Aeroplane) valid until 11 August 2024, a Class 1 aviation medical certificate valid until 16 May 2024, and reported a total flying time of about 14,500 hours with about 3,100 hours of those being on the SAAB 340B. They had joined as a SAAB 340B captain with Lulutai Airlines in September 2020.

On 30 September 2023, the captain had conducted a biannual operational competency assessment (OCA) on the SAAB 340B in a simulator, in accordance with the operator's process. The captain was found to be competent with comments on the sequences performed to a satisfactory standard. The OCA covered amongst other assessments, engine malfunction, landing with a flap malfunction, memory items and emergency evacuation procedures, however the assessment did not cover hydraulic system emergencies requiring the use of the auxiliary hydraulic system.

First officer

The first officer (FO) held a Commercial Pilot Licence (Aeroplane) valid until 11 August 2024, a Class 1 aviation medical certificate valid until 16 May 2024, and reported a total flying time of about 5,702 hours, having flown about 2,726 hours of those in the SAAB 340B. They had joined Lulutai Airlines in September 2020 as a first officer on the SAAB 340B, Harbin Y-12, and Jetstream J32.

On 25 June 2023, the FO conducted a biannual OCA on the SAAB 340B in a simulator, in accordance with the operator's process. The FO was found to be competent with nil additional training required by the independent flight examiner. The OCA identified that the FO had performed well and covered amongst other assessments, engine malfunction, landing with a flap malfunction, memory items and emergency evacuation procedures, however the assessment did not cover hydraulic system emergencies requiring the use of the auxiliary hydraulic system.

Licenced Aircraft Maintenance Engineer

The licenced aircraft maintenance engineer (LAME) for the SAAB 340B held a current Tongan Certificate of Validation Foreign Aircraft Maintenance Engineer Licence, based on their aircraft maintenance engineer licence which was issued by the General Directorate of Civil Aeronautics (DGAC) of Guatemala. The LAME was approved to exercise their ratings which were on their Guatemalan licence, including the SAAB 340 airframe and engine. The LAME was primarily responsible for the airworthiness of the SAAB 340B and the operator was to use additional appropriately licenced LAME's to conduct aspects of maintenance the LAME were not certified for.

Aircraft information

General

The SAAB 340B is a low-wing, pressurised regional commuter aircraft, fitted with 2 General Electric (GE) CT7-9B turboprop engines.

A3-PUA, serial number 408, was manufactured in Sweden in 1996 and first registered in Tonga in April 2016. It was first registered with Lulutai Airlines Limited in September 2020. At the time of the occurrence, the airframe had accumulated 39,094.5 hours total time in service.

Hydraulic system overview

The SAAB 340 hydraulic system consists of a main and an auxiliary hydraulic system.

The main system is powered by a single electrically powered hydraulic pump, controlled by a 3-position switch (off-auto-override). The switch is in the 'auto' position for normal operation, which allows the pump to be powered when hydraulic pressure drops below a set value. If there is an issue with the automatic operation feature, the switch can be selected to 'override' to manually control pump operation. If the system needs to be deenergised, the pump can be selected too 'off'.

The main hydraulic system provides hydraulic power to the flaps, landing gear, inboard and outboard brakes, and nosewheel steering through 4 hydraulic accumulators:[6]

- emergency – landing gear emergency uplock release actuator
- main – flaps, landing gear, nose wheel steering
- outboard brakes
- inboard brakes

The auxiliary hydraulic system consists of a separate hydraulic fluid reservoir and a hand pump. The hand pump does not have the capacity to operate all of the hydraulic systems simultaneously. A 3-position selector valve separately directs pressure to the main, outboard brakes, and inboard brakes accumulators.

Hydraulic system warnings are indicated to the flight crew through an amber caution light on the central warning panel (CWP). A master caution light would also illuminate, along with an audio chime. This warning is triggered, amongst other things, for low pressure in the main or emergency hydraulic accumulators. Additionally, low pressure in either of the brake accumulators would also result in low pressure in the main accumulator, therefore low pressure in any accumulator would trigger the warning system.

Hydraulic indicators located on the centre pedestal on the flightdeck (Figure 2) provided information to the flight crew regarding the status of the hydraulic system. These indicators provided information for the main hydraulic fluid quantity and accumulator pressure for the main and auxiliary hydraulic systems, as well as the inboard and outboard brake accumulators. The indicators were powered through 2 different electrical

[6] An accumulator is a device for storing energy in hydraulic system. It can also act as emergency source of pressure of fluid, and act as pump back-up at peak load.

systems. The left electrical bus provided power to the auxiliary and outboard brakes accumulator indicators through a circuit breaker (HYDRAULIC – PRESS IND) located on the captain's left circuit breaker panel. The right electrical bus provided power to the hydraulic quantity indicator, and main hydraulic and inboard brakes accumulator indicators through a circuit breaker (HYDRAULIC – PR IND / QTY IND) located on the FO's right circuit breaker panel.

SAAB 340B operational documentation

General

SAAB prepared an aircraft operations manual (AOM) specifically to provide guidance to flight crew operating the SAAB 340B. The AOM provided information including general information about the aircraft, its systems, and checklists for normal, abnormal, and emergency procedures. The operator based their checklists on the SAAB documents for their operational purposes, and compiled them in a quick reference handbook (QRH).

Normal checklists

The AOM and QRH provided checklists to cover normal operations of the aircraft, from a preparatory check, through to a parking check. Of the items to be checked, circuit breakers were only checked on the 'before engine start' check, and a check of the hydraulics was listed on the 'before engine start' and 'landing' checklists.

Abnormal checklists

The SAAB AOM abnormal procedures provided guidance on the checklist use, including:

> The Malfunction, (Abnormal and Emergency) checklists are intended to be performed in a read− and−do manner and as such need not be committed to memory. The only exception is recall (memory) items indicated by a star (*) in the checklist. The number of recall items has been kept to a minimum.

and:

> WHEN A MALFUNCTION SITUATION IS EXPERIENCED, IT SHALL BE **POSITIVELY IDENTIFIED** BEFORE ANY ACTION IS TAKEN … [original emphasis included].

Hydraulic system checklists

The QRH provided abnormal checklists for 2 hydraulic system issues, the first for hydraulic CWP light illumination (Appendix A: Lulutai Airlines Abnormal checklist - HYDR light on), and one for hydraulic fluid loss (see Appendix B: Lulutai Airlines Abnormal checklist - hydraulic fluid loss). SAAB had updated their abnormal checklist for hydraulic fluid loss on 1 June 2017. The operator had maintained their abnormal checklist at an earlier version. The revision date for the checklist in the aircraft was 1 June 2017, and the latest electronic version held by the operator was dated 1 June 2022. Both versions of the operator's checklist contained the same information for the hydraulic light and fluid loss checklists. While wording had been amended in the SAAB abnormal checklist for clarification, the intent was the same.

In this accident, the hydraulic light was not illuminated on the CWP. This light would illuminate if there was low hydraulic pressure in any of the hydraulic accumulators.

Abnormal checklist – hydraulic fluid loss

The hydraulic fluid loss checklist provided a specific and methodical process to follow in the event of suspected fluid loss. The first item, a memory recall item, was to immediately turn off the electric hydraulic pump when the hydraulic quantity reduction was identified. The remainder of the checklist process varied depending on the symptoms being presented to the flight crew.

Notes were also provided on the operator's hydraulic fluid loss checklist to provide further guidance to the flight crew. The beginning of the checklist identified:

- A large number of hand pump strokes are required for flap and landing gear operation.
- Stroke resistance characteristics vary from very light to rather heavy.
- Position of handpump selector is important. Normally center for gear and flaps and at the outer end (left/right) for inboard/outboard brakes. Small adjustments to these positions might be necessary to achieve enough pressure.
- A large number of hand pump strokes and continuous pumping is required to achieve and maintain enough brake pressure.
- Normal action with a faulty hydraulic pump is to tow the aircraft on ground. It is a challenging task to taxi on ground with just the handpump as pressure source.
- Direct entry into this procedure is when Hydraulic Quantity is low. The majority of Hydraulic fault related procedures refers to this procedure for Landing Gear, Flaps and Brake operation.
- Even though emergency extension does not require the Landing Gear handle to be selected down it shall be selected down for the obvious reason of agreeing with the Landing Gear position. It is also required for anti skid function.
- Maximum speed for gear normal or emergency extension is 200 KIAS.

An amendment to these notes had been made in the SAAB AOM on 1 June 2017, however had not been incorporated into the operator's checklist:

- The operational capability of the emergency hydraulic system (hand pump system) is adequate to perform a normal safe landing and stop. The amount of fluid is however limited and unnecessary braking or nose wheel steering should be avoided during the landing roll out to make a safe stop on the runway. The safest action is to shut down engine, using the fire handles, park the aircraft on the runway and request towing.

The 'after landing' section of the operator's checklist provided a warning:

- WARNING

  Do not taxi with a faulty hydraulic pump. Once the aircraft has come to a stop after landing, shut down engines with Fire Handles to prevent uncontrolled forward thrust.

Tow the aircraft to a safe parking. Ensure that AUTOCOARSEN[7] is selected to OFF prior to shutting down the engines.

- NOTE

During taxiing with a non-functioning hydraulic pump, the hydraulic functions will be abruptly lost when hydraulic accumulator pressure falls below approximately 1650 psi.

The wording for the 'after landing' section, 'warning' and 'note' had also been amended in the latest SAAB amendment, but not in the operator's checklist:

- WARNING

Do not taxi with brake system unpressurized. Once the aircraft has come to a stop after landing, shut down engines with Fire Handles to prevent uncontrolled forward thrust. Be aware that at low power setting it takes approximately 45 seconds for the engine to consume the remaining fuel before ceasing. Tow the aircraft to a safe parking.

Ensure that AUTOCOARSEN is selected to OFF prior to shutting down the engines.

- NOTE

During taxiing with a non functional hydraulic pump, use nose wheel steering and brakes with great care. The functions will be abruptly lost when hydraulic accumulator pressure falls below about 1650 psi.

The abnormal checklist had different procedures to follow, depending on whether symptoms showed 'either' or 'both' the hydraulic quantity and main pressure were low. If either were low, the landing gear and flaps were to be pumped down with the auxiliary system. If both were low, the emergency landing gear handle was to be pulled and the flaps were not to be operated. The landing reference speed also varied depending if both, one, or no braking systems were available.

Meteorological information

Weather conditions reported to the crew from air traffic control (ATC) for their return to Fua'amotu International Airport indicated that there was a breeze from the east at 7 kt, visibility in excess of 10 km, and a temperature of 29 °C. The sky was mostly clear with a few clouds at 1,000 ft.

Aerodrome information

Fua'amotu Airport was a certified aerodrome situated about 7 NM to the south-east of Tonga's capital city, Nuku'alofa. The airport was serviced by a number of major international air carriers, and one domestic air carrier.

The airport was at an elevation of about 100 ft above mean sea level and had 2 crossing runways. The main sealed runway was 2,671 m long and orientated in a south-east, north-west direction, and the grass cross-runway was 1,330 m long and orientated in a north-south direction.

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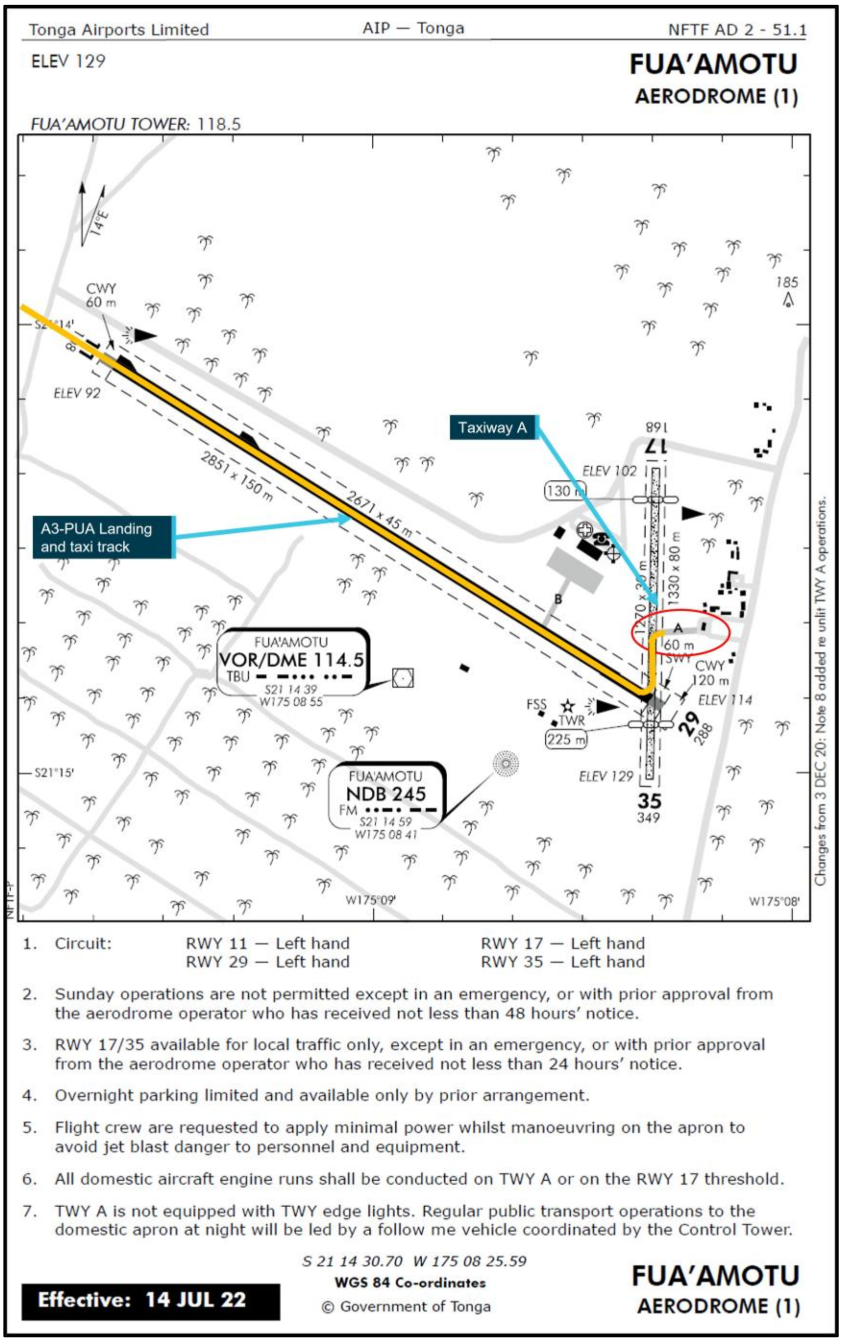
[7] Autocoarsen system: The autocoarsen system is installed to achieve a fast reduction in windmilling drag during take-off, approach and go−around in case of engine failure. The system also responds to temporary engine malfunctions such as momentary fuel or air flow interruption.

The Tonga Aeronautical Information Publication (AIP) promulgated by Tonga Airports Limited provided information to pilots on the operations specific to each aerodrome (Figure 5).

Figure 5: AIP aerodrome information for Fua'amotu Airport



Source: Tonga Airports Limited, annotated by the ATSB accredited representative to Tonga Chief Investigator

Flight recorders

Introduction

Tonga Civil Aviation Office (TCAO) reported that following the accident, and in accordance with the procedure in the operator's emergency response plan and maintenance management manual, the flight data recorder (FDR) and cockpit voice recorder (CVR) were removed from the aircraft and were quarantined by the operator at their head office.

Cockpit voice recorder

TCAO recovered the CVR from the operator and it was packaged at the TCAO offices in a cushioned case by Australian Transport Safety Bureau (ATSB) investigators for transport. The Fairchild (Lockheed Martin) A200S CVR was taken to the ATSB facilities in Canberra, ACT, Australia. A successful download of the accident flight was achieved, with 30 minutes of high-quality audio, and 120 minutes of standard-quality audio recovered. Generally, CVR channels containing crew audio were of a good quality. However, the cockpit area microphone (CAM) channels were low in volume and contained mostly noise.

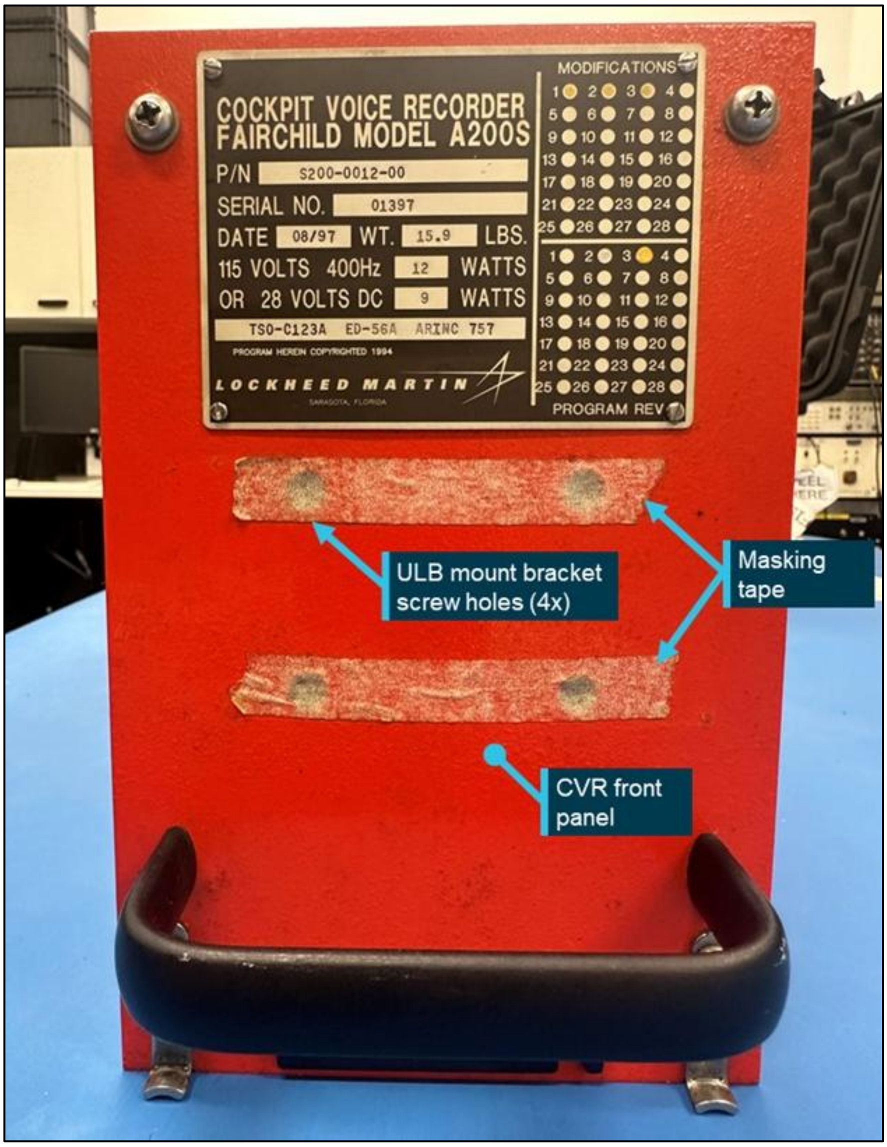
Normally, CAM channels capture the cockpit conversations, alert sounds and engine sounds, among others. However, even with the gain turned up high, normally expected sounds could not be heard, except for a small number of alert sounds. This was consistent across both the high-quality and standard-quality channels, suggesting that the issue resulting in the very low recording volume was due to an external source, not the recording on the CVR.

The CVR recorded intercom conversations on the flight deck between the captain, FO, and the chief executive officer (CEO). The recording indicated that conversations including the CEO were during the cruise phase of flight, limited to times outside of critical phases of the flight. The conversations were general in nature. When the issue with the hydraulic system was identified, through to the aircraft turning back to Fua’amotu, discussion was limited to the flight crew. However, during the air return to Fua’amotu Airport, the flight crew did take the time to explain the issue to the CEO and their reasoning for returning.

CVRs and FDRs are required to be fitted with underwater locator beacons (ULB) in accordance with Tonga Civil Aviation Rules, Part 121. These devices are designed to survive accidents and activate on contact with water. When functioning correctly, they will emit a pulsing signal every second, for at least 30 days. This enables recovery teams to conduct a targeted underwater search, tracking the pulsing signal to the recorders.

When the CVR was received from the operator, ATSB identified that there was no ULB or ULB mount bracket attached, and there was masking tape over the mounting bracket screw holes in the front panel (Figure 6). While it is not unusual to remove the ULB from flight recorders for transport due to the ULB containing a lithium battery, this recorder had indications that the ULB had not been attached to the CVR at the time of the accident.

Figure 6: CVR with masking tape over ULB mounting holes



Source: ATSB

Flight data recorder

The FDR was delivered to ATSB investigators[8] by the operator at the aircraft on 21 December 2023, when a download was then carried out.

The ATSB successfully downloaded the memory from the Fairchild (L3 Harris) F1000 FDR installed in A3-PUA. The FDR contained 45 hours of valid flight data. However, the altitude profile, and flight duration for the last recorded flight was not consistent with the accident flight.

[8] An ATSB investigator was assigned as an Accredited representative to the Tonga Chief Investigator under Annex 13 of the International Civil Aviation Organization.

The data included a day and month parameter, which indicated that the last flight recorded was on 11 July, but the year was not recorded. A comparison with the flight logs indicated that the last correctly recorded flight on the FDR was on 11 July 2023.

A large amount of unchanging data, recorded after the last correctly recorded flight was consistent with data compression when the FDR was operating, however there was no input data being provided to it.

Flight data acquisition unit

During aircraft operation, various airframe and engine parameters are collected and processed by the flight data acquisition unit (FDAU) before being transmitted and stored into the FDR.

As a result of identifying that the FDR was not recording, an examination of the recording system was carried out by the Tonga Chief Investigator (CI) and ATSB investigators (Table 1). It was confirmed that the FDR was being provided power, so the FDAU system was examined. It was confirmed that no caution lights were illuminated on the flight data entry panel (FDEP), or on the FDAU indicating that no power was being supplied. Further examination found that the power circuit breaker for the FDAU (DATA AQUIS PWR) was extended (tripped) and was fitted with a locking collar to prevent it from being reset.

The operator's flight operations manual (FOM) had a circuit breaker policy in Chapter 18.4.1 stating:

> Unless there is an overriding operational requirement, a circuit breaker which trips during flight should not be reset. Strict following of QRH pertaining procedures will indicate how/when a circuit breaker is to be reset or recycle.

A note in the policy added:

> A Technical Log entry must be made covering the fault and identifying the circuit breakers that have tripped or been reset, or have been cycled.

The examination by the investigation indicated that the FDAU had an electrical fault that resulted in its circuit breaker continually tripping if reset.

Table 1: FDAU system examination process and results

Process	Results
Ground power applied to the aircraft, and aircraft electrical system energised	No lights on the FDEP, no lights on the FDAU
Avionics master turned on	No lights on the FDEP, no lights on the FDAU
Collar removed from DATA AQUIS PWR circuit breaker and reset	Circuit breaker tripped after 1 second. Circuit breaker left tripped.]
Aircraft electrical system de-energised	-
FDAU removed	-
Aircraft electrical system energised	No lights on the FDEP, no lights on the FDAU
Avionics master on	No lights on the FDEP, no lights on the FDAU

DATA AQUIS PWR circuit breaker and reset	Circuit breaker remains in, and the FDAU fault red warning light illuminates on the FDEP
Power off and circuit breaker pulled	-
FDAU and its associated rack connectors checked	No bent pins or damaged connectors
FDAU reinstalled	-
Aircraft electrical system energised	No lights on the FDEP, no lights on the FDAU
Avionics master on	No lights on the FDEP, no lights on the FDAU
DATA AQUIS PWR circuit breaker reset	Circuit breaker tripped after 1 second. Circuit breaker left tripped
Power off	Examination complete.

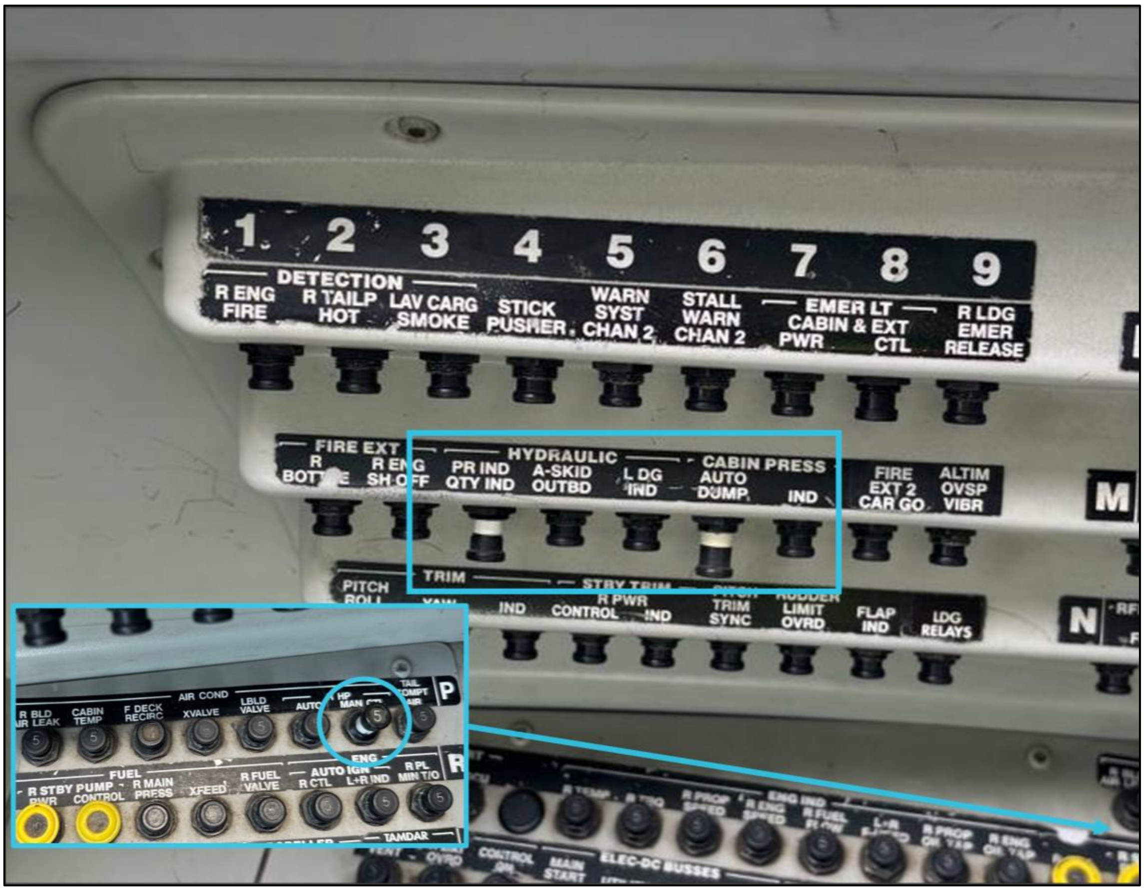
Wreckage and impact information

Initial inspection

The Lulutai Airlines LAME that maintained A3-PUA arrived shortly after the accident. They spent some time looking around the aircraft and taking photos. They did not identify any visible hydraulic leaks at that time. The LAME reported that they entered the flight deck and identified 2 tripped circuit breakers on the right circuit breaker panel (Figure 7). The tripped circuit breakers were:

- CABIN PRESS – AUTO DUMP
- HYDRAULIC – PR IND / QTY IND

Figure 7: Photo taken by the LAME shortly after the accident showing right circuit breaker panel with tripped circuit breakers



Source: Supplied, annotated by the ATSB accredited representative to Tonga Chief Investigator

They reported that they exited the flight deck with the aircraft configured as it was when they entered, for the purposes of the investigation. Through consultation with TCAO, the operator levelled and stabilised the aircraft on jacks and defueled it.

The CI and ATSB investigators visited the accident site for a detailed visual examination of the aircraft on 20 December 2023. Key points noted:

- hydraulic pressure and quantity circuit breaker (HYDRAULIC – PR IND / QTY IND) tripped on the right circuit breaker panel
- cabin pressure auto dump circuit breaker (CABIN PRESS – AUTO DUMP) tripped on the right circuit breaker panel
- right air conditioner high pressure manual control circuit breaker (AIR COND – R HP MAN CONT) tripped on the right circuit breaker panel
- main hydraulic system reservoir quantity indicator in nose wheel well indicated empty
- auxiliary hydraulic system reservoir was full
- right main landing gear leg folded aft due to a broken drag link, most likely as a result of impacting the concrete wall (Figure 8)
- creasing in the aft region of the right engine nacelle, most likely from the right landing gear wheels impacting its lower surface (Figure 8)
- damage to 2 propeller blades on the right propeller (Figure 9)

- damage to the nosewheel landing light, and the nosewheel steering had rotated about 180 degrees, most likely as a result of impacting the concrete wall.

The tripped 'CABIN PRESS – AUTO DUMP' and 'AIR COND – R HP MAN CONT' circuit breakers were most likely associated with wiring damage during the right landing gear leg collapse.

Figure 8: Right landing gear damage and broken drag link

Source: Supplied and TCAO, annotated by the ATSB accredited representative to Tonga Chief Investigator

Figure 9: Right propeller blade damage

Source: Supplied, annotated by the ATSB accredited representative to Tonga Chief Investigator

Hydraulic system examination

The LAME assisted the investigators by pressurising the hydraulic accumulators through the auxiliary hydraulic system hand pump, to check the system for potential hydraulic leaks. As each dump valve on each accumulator was activated, hydraulic fluid was observed leaking from an area above the right landing gear leg, and a constant flow was identified when the hand pump was actuated with the auxiliary hydraulic system pump selected to 'main accumulator'. The source of the leak was unable to be identified during this initial examination due to the position of the right landing gear leg and the subsequent structural damage in the nacelle.

The aircraft electrical system was energised and the 'HYDRAULIC – PR IND / QTY IND' circuit breaker was reset. The circuit breaker remained in, and the following indicators powered 'on':

- hydraulic quantity

- main hydraulic accumulator pressure
- inboard (INB) brake accumulator pressure.

With the indicators powered, the main hydraulic quantity indicator moved up to ‘0’ (main hydraulic tank empty) from off-scale (unpowered). To assist with the examination, the inboard and outboard brake accumulators were pumped up with the auxiliary hydraulic pump, providing a pressure indication on each system. The ‘HYDRAULIC – PR IND / QTY IND’ circuit breaker was then pulled, and the main hydraulic quantity indicator dropped off-scale, and the inboard brake accumulator pressure dropped to ‘0’. Resetting the circuit breaker brought the indicators back on-line.

After the initial on-site examination of the aircraft, the operator relocated it to their hangar facility. The CI and ATSB investigators revisited the aircraft on 14 February 2024 to conduct further examination to identify the source of the hydraulic leak. The operator had organised for the right landing gear leg to be removed to facilitate the examination. Damaged structure above where the landing gear leg and wheels had contacted the right nacelle was removed to provide access to the hydraulic plumbing. Further leak checks were carried out, and leaks were identified from several creased and cracked pipes (Figure 10). This damage was very likely associated with damage incurred during the accident sequence.

Figure 10: Crushed, cracked, and leaking hydraulic pipes

Source: TCAO

The aircraft electrical system was then powered up, and the ‘HYDRAULIC – PR IND / QTY IND’ circuit breaker reset to provide electrical power to its hydraulic system indicators. Power remained applied for about 1 hour and 15 minutes (the accident flight was 45 minutes), however the circuit breaker did not trip during this time.

Flight crew training

Recurrent training

The operator outsourced the majority of its aircrew check and training to international flight examiners proficient on the SAAB 340. Depending on the recurrent training required, it was conducted either in the aircraft, or in a Level C or D full flight simulator (FFS).[9] The Crew Training and Standards Manual (CTSM) stated in Chapter 3.6, Use Of Flight Simulators And Training Devices:

> Whenever possible, training is to be completed using Flight Simulators or Training Device. This is to minimize the inherent risks involved with using the aircraft to simulate emergency and/or unsafe condition.

Chapter 4.7.3, Recurrency, also noted:

> The candidate will demonstrate the ability to complete an Operational Competency Assessment and proficiency in assessing the standard of performance & identifying areas of Weakness to the satisfaction of the Flight Examiner or CAD Authorized Person.

Chapter 6 of the CTSM discussed the 24-month recurrent, evidence-based training program for the SAAB 340B. The operator kept comprehensive records for the flight crew recurrency training. The records indicated that the flight crew were undertaking their operational competency assessments at the required intervals, and were performing to an acceptable standard.

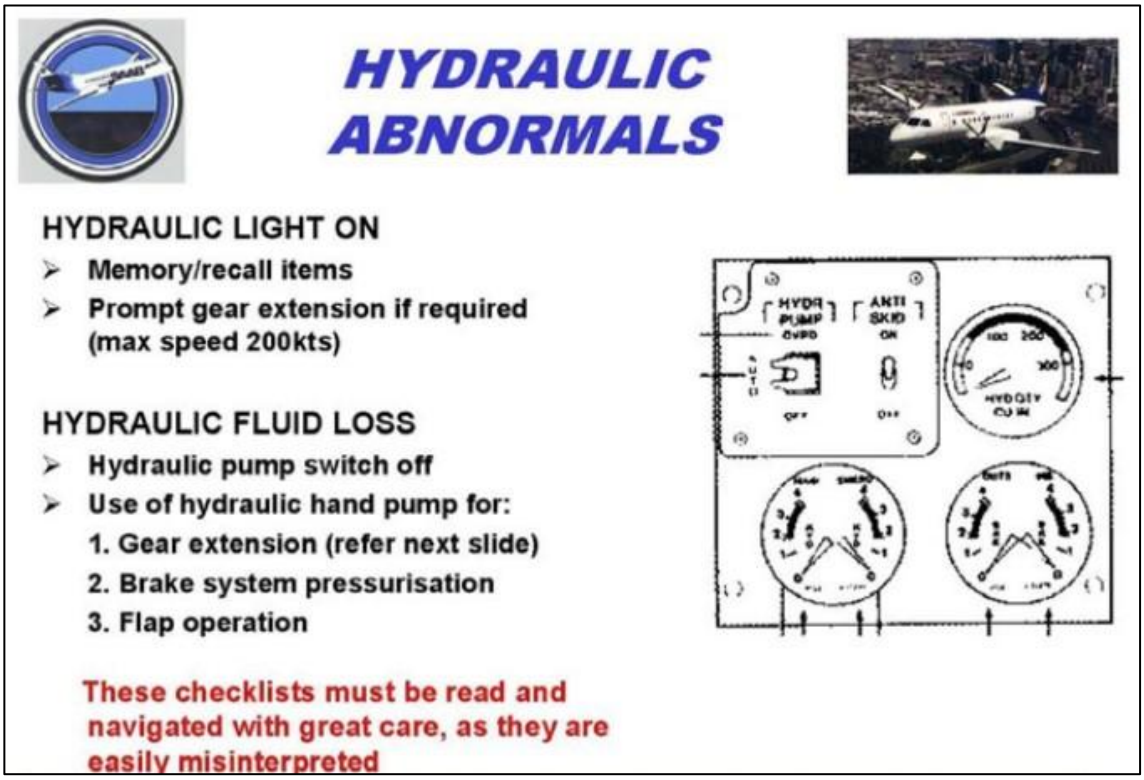
Flight crew hydraulic systems understanding

The operator's CTSM evidence-based training program for flight crew provided information for hydraulic system abnormal situations (Figure 11). The program training slide noted in red:

> These checklists must be read and navigated with great care, as they are easily misinterpreted.

9 Level C FFS have 6 axis motion / night & dusk visuals / dynamic control loading / higher fidelity, and Level D FFS have 6 axis motion / night, dusk & day visuals / dynamic control loading / highest fidelity

Figure 11: CTSM manual hydraulic abnormals training slide



Source: TCAO

The program training slide also contained information regarding the capabilities of the auxiliary hydraulic system hand pump, including landing gear extension, wheel brake system pressurisation, and flap operation.

Both the captain and FO were able to describe the basic components of the hydraulic system during interviews with investigators, however their operational knowledge of the system was limited to confirming that the auxiliary hydraulic system could only be utilised for lowering the landing gear.

Crew resource management

Crew resource management (CRM)[10] plays an important role in workload management and communication in the cockpit, particularly during non-normal situations. It is the effective use of all available information by all crew to reduce error and increase the efficient and safe operation of the aircraft. The normal benefits of CRM is to load-shed, delegate tasks, ensure all crew have common understandings, and confirm prioritisation of actions in non-normal situations to ensure any emergency is addressed in accordance with the manufacturers checklists.

The Flight Safety Foundation Approach and Landing Accident Reduction tool kit briefing note 2.2 on CRM states that:

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10 Crew resource management (CRM) refers to the effective use of all available resources: human resources, hardware, and information to achieve safe and efficient operation.

> Because CRM is a key factor in flight crew performance and in their interaction with automated systems, CRM has a role to, in some degree, in most aircraft incidents and accidents.

It further details that CRM can be affected by the organisation's safety culture and policies, belief that correct decisions have been made although deviating from standard operating procedures, fatigue and inadequate countermeasures to restore alertness and reluctance to accept the human factors play a part in aircraft landing accidents.

The briefing note also highlights that deviations from standard operating procedures (SOP) are usually not deliberate and that SOP's can be perceived as limiting the flight crew's judgement and subsequent emergency decision making:

> Without denying the captain's emergency authority, SOP's are safeguards against biased decision making. Effective flight crew decision making often requires a joint evaluation of options prior to proceeding with an agreed-upon decision and action.

The operator had a requirement for all new flight crew to undertake CRM training within 1 year of joining, then refresher training every 2 years. The captain last completed CRM refresher training on 22 June 2022, and the FO on 9 June 2022.

The operator's FOM provided guidance in Chapter 17.4, Cockpit Management, detailed a policy:

> All flight deck personnel will work in a co-operative but inquiring manner at all times, Captains will encourage full participations from all other crew members in the operation of the aircraft. The captain has ultimate authority over the final disposition of the aircraft.

Chapter 17.5 Cockpit Management & Duty Policy stated amongst other things:

> The Captain will exercise command of the aircraft during abnormal / emergency situations but may delegate flying duties to the First Officer.

The FOM, Chapter 17.11, Crew Resource Management went on to include a statement:

> Crew Resource Management (CRM) is the effective utilisation and management of all available resources, including information, equipment and people, to achieve safe and efficient flight operations. Crew Resource Management (CRM) principles and tools are an essential element of safety and good airmanship.

Aircraft maintenance

Maintenance practices

The operator provided a maintenance management manual (MMM) as part of their Air Transport Operator Exposition, as required under Tonga Civil Aviation Rule Part 119.81. The manual stated:

> This Manual sets out management philosophies, policies, organisation, structure, responsibilities and documents specific procedures that are applicable to all levels of the organisation, such as the Safety Management System.

The MMM Chapter 10.4 required that any defect found during an inspection was to be entered onto a task card and added to the work pack checklist, and any deferred defects not resolved in the maintenance visit was to be recorded on the task card with a cross-reference to a defect reference number, and recorded in the aircraft logbook. Chapter 11.5 went on to say:

> …Defects found during scheduled maintenance visits must be recorded on maintenance work sheets and rectification recorded and certified in the Maintenance Providers Task Cards or directly in the logbook. All such defects found by the contracted maintenance provider must be notified to the Maintenance Controller.
>
> The Maintenance Controller must plan the rectification of defects, taking into account factors such as time limitations imposed by the MEL, availability of spares and availability of the aircraft…

At the completion of maintenance, the MMM, Chapter 16.4 required that the maintenance carried out was to be vetted to ensure work carried out complied with the approved maintenance programme. The maintenance controller was required to review the work packs and logbook entries for the completed job to ensure that:

> (a) Maintenance action has been recorded fully and accurately…
>
> (f) Discrepancies arising during the conduct of maintenance have been processed in accordance with the Maintenance Provider Part 145's procedures
>
> (g) Defect incidents have been reported in accordance with the Maintenance Provider Part 145's procedures.

Maintenance for the aircraft was conducted by the operator's in-house maintenance section. A dedicated type-rated LAME was employed to oversee and conduct maintenance on the aircraft, working under the chief engineer.

A review of the aircraft maintenance records, including technical logs and work packs by the investigation showed a consistent approach to maintaining the aircraft to its appropriate maintenance schedule, and the logging and rectification of defects.

A minimum equipment list (MEL)[11] had also been produced by the operator, and developed from the manufacturers master minimum equipment list (MMEL) document. The MMM, Chapter 11.6, described the defect deferral process using the MEL. It stated:

> …If a deficiency is assessed as a defect it may be deferred but only in accordance with the provisions of the Approved Minimum Equipment List (MEL)…

Evidence was also available to indicate that the MEL was being utilised as required.

Maintenance history

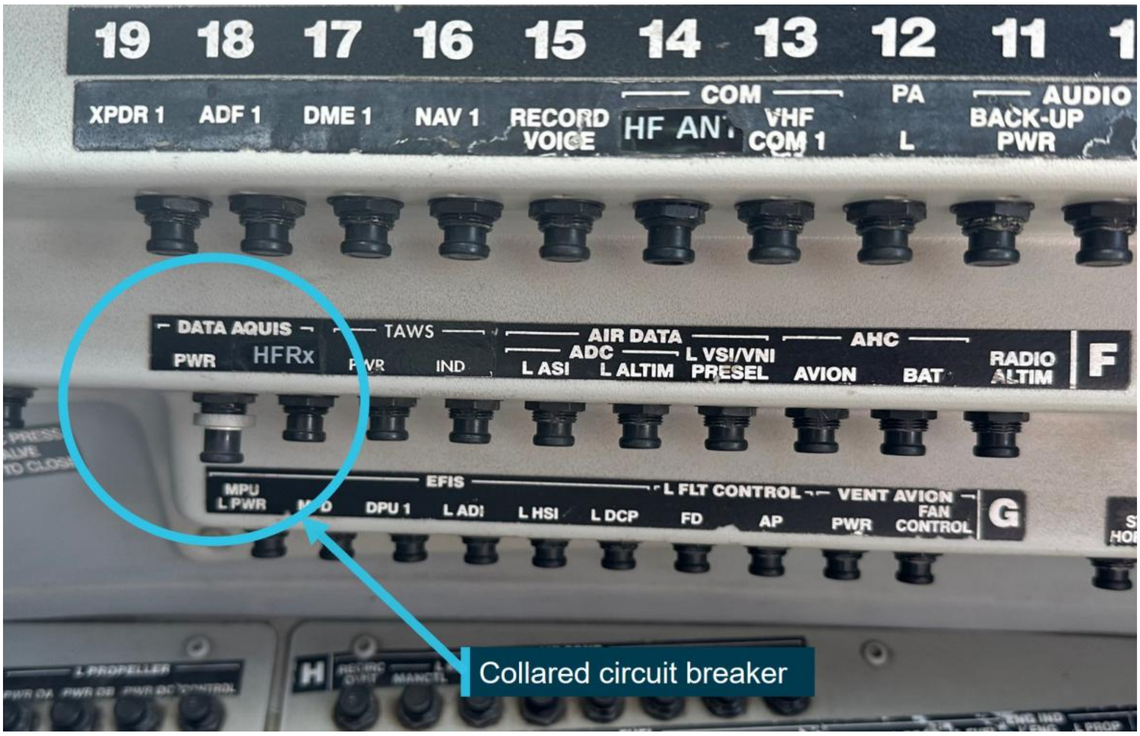
A review of the maintenance records identified that maintenance was carried out on schedule, and defects were rectified when identified. There were, however, ongoing troubleshooting activities for the avionics systems, including high frequency (HF) radio receiving and transmitting issues, and intermittent issues with hydraulic accumulators not holding pressure, and units were either recharged with nitrogen, or replaced. There was evidence of troubleshooting these issues as they arose, and rectifications and resolutions detailed. No details regarding issues with the FDR were identified.

HF radio issues were related to transmitting and receiving at various stages. Due to the on-going issues with the HF system, the LAME explained that they isolated the power and placed a collar on the circuit breaker to remove power to the HF system. (The circuit

[11] A minimum equipment list details items of aircraft equipment that may be inoperative for a specified time, subject to specified conditions, to allow for continued safe operations.

breaker was also collared to prevent flight crew from re-engaging the circuit breaker.) As the task was not recorded in the aircraft's technical log it could not be determined exactly when the circuit breaker was collared, although it is likely it occurred around 1 December 2023 while troubleshooting a reception issue with the HF radio. The circuit breaker was located on the left pilot's side circuit breaker panel, at location 'F19' (Figure 12).

Figure 12: Collared data acquisition power circuit breaker



Source: ATSB

Minimum equipment list use

As identified during the data recovery for the CVR, it was noted that the ULB had not been installed on the CVR for quite some time. Investigators could not identify in the aircraft's paperwork when the ULB was removed. It was however identified by the avionics LAME as being missing during a 2-yearly avionics inspection, albeit documenting that it was missing from the FDR. The engineer performing the inspection recalled asking the chief engineer about the ULB being missing. They were told that the battery had expired and had been removed for battery replacement. The operator confirmed to investigators that no follow-up action was taken to order a replacement ULB and mount or enter it into the aircraft's MEL.

As the ULB was missing from the CVR, this should have been entered as a defect in the MEL as the ULB was required to be fitted. Under the approved MEL (Figure 13), it was permissible for the CVR to be unserviceable for a maximum of 72 hours, and no more than 8 further flights, provided that the FDR was serviceable.

Figure 13: A3-PUA MEL extract for the CVR

1. System & Sequence numbers	2. Item	3. Category	4. Number Installed	5. Number required for Dispatch	6. Remarks or Exceptions
23	COMMUNICATIONS				
70–1	Cockpit Voice Recorder System	A	1	0	★ May be inoperative provided: (a) The aircraft does not exceed 8 further consecutive flights with the Cockpit Voice Recorder inoperative. (b) A maximum of 72 hours have elapsed since the Cockpit Voice Recorder was found to be inoperative. (c) Any Flight Data Recorder required to be carried is operative. OR
		–	1	–	★ For non–EASA operators: As required by National Aviation Regulations.

Source: Operator

The operational and maintenance crews did not identify that the FDR was unserviceable. Had it been identified, it should have been entered as a defect in the MEL. Under the approved MEL (Figure 14), it was permissible for the FDR to be unserviceable for a maximum of 72 hours, and no more than 8 further flights, provided that the CVR was serviceable.

Figure 14: A3-PUA MEL extract for the FDR

1. System & Sequence numbers	2. Item	3. Category	4. Number Installed	5. Number required for Dispatch	6. Remarks or Exceptions
31	INDICATING&RECORDING				
30–1	Flight Data Recorder System	A	1	0	★ May be inoperative provided: (a) The aircraft does not exceed 8 further consecutive flights with the FDR inoperative. (b) A maximum of 72 hours have elapsed since the FDR was found to be inoperative. (c) Any Cockpit Voice Recorder required to be carried is operative. NOTE: The FDR is considered inoperative if loss of flight recording function is evident during the pre–flight check, or need for maintenance has been identified without identification of failure origin, or analyses of recorded data or maintenance actions have shown that more than 5% of required parameters are not being recorded properly. NOTE: If an Underwater Locator Beacon (ULB) is required by regulation to be fitted to the FDR and this ULB is inoperative, the associated FDR is considered to be inoperative. OR
		–	1	–	★ For non–EASA operators: As required by National Aviation Regulations.

Source: Operator

Related occurrences

Hydraulic systems related

United States

SAAB 340A, N341CA, Covington, Kentucky, on 9 March 1987

After a hydraulic system malfunction, the captain returned the SAAB 340B to the airport to exchange aircraft. Another company pilot who had completed a day of flying and was asked to taxi the aircraft to the maintenance hangar. The departing captain was in the process of manually pumping the hydraulic system to sufficient pressure to ensure braking action. The repositioning captain took the left seat and began to taxi to the hangar. They confirmed the ramp area required power and braking to manoeuvre away from a jet aircraft and a fuel truck. The pilot lost brake pressure and placed propellers in reverse to prevent collision with a truck. Collision was imminent so the pilot elected to shut down the engines. As the propellers transitioned from powered reverse, a burst of thrust accelerated the aircraft, resulting in an impact with a fuel truck and jet. Examination determined that the hydraulic pump internal driveshaft failed due to an improperly secured retainer nut. The company has since made it mandatory for 2 pilots to be on a taxied aircraft.

The Netherlands

LV2015086 - Runway excursion after leakage in hydraulic system, involving SAAB 340B, G-LGNJ, Rotterdam The Hague Airport, 30 September 2015

Shortly after take-off from Rotterdam The Hague Airport , a SAAB 340B operating as a passenger flight experienced a main hydraulic system failure on 30 September 2015. The aircraft returned to the airport after having flown for a while in the nearby holding area for trouble shooting. A safe landing was executed and the aircraft came to a stop on the runway, but during the engine shutdown the aircraft moved forward and to the left. The aircraft came to a full stop into the grass of the runway's left shoulder. An emergency evacuation of the passengers followed.

The investigation showed that the main hydraulic system failure occurred due to hydraulic fluid leakage of a broken down lock swivel of the right hand main landing gear. The swivel was broken due to fatigue. For replacement of these swivels the aircraft manufacturer had issued a Service Bulletin in 2013.

The layout of the abnormal hydraulic malfunction checklists contributed to the outcome as the flight crew missed the alternative engine shut down procedures during ground operations with low hydraulic fluid quantity and low hydraulic pressure. This resulted in forward engine thrust and uncontrolled movement of the aircraft. Both the manufacturer and the operator took measures to improve the checklists to prevent reoccurrence.

Furthermore, the investigation revealed that the flight crew did not immediately execute the memory item to turn off the electric hydraulic pump associated with the hydraulic failure, and noted that the abnormal checklist was lacking information about the limitations of the auxiliary hydraulic hand pump system.

Bahamas

SAAB 340A, C6-EAR, Lynden Pindling International Airport, Nassau, on 9 January 2024

On the 9 January 2024, a Saab 340A operating as a commercial cargo services was involved in a taxiway excursion at the Lynden Pindling International Airport, Nassau, Bahamas.

During taxi to position to the active runway for departure, the pilot in command observed a loss of hydraulic pressure. Subsequently, the flight crew lost control of the aircraft as they were unable to steer the aircraft or use the braking system. The aircraft exited the paved surface of the taxiway to the left, and came to a stop in an area of grass after travelling a distance of some 98 feet from the edge of the paved surface of the taxiway, at a position of approximately 130 feet from the entrance of the apron.

The aircraft received minor damage to the nose landing gear. There were no injuries reported in relation to this occurrence.

Post-accident analysis and inspection of the aircraft hydraulic system was conducted, in accordance with the manufacturer’s procedures, and revealed that a faulty relay switch was the root cause of the hydraulic pressure loss. The faulty switch was replaced with a serviceable part and the aircraft was subsequently returned to service.

Australia

AO-2024-047 - Hydraulics system failure involving Fairchild SA227-DC, VH-WAJ, at Perth Airport, Western Australia, on 12 August 2024

On the morning of 12 August 2024, a Fairchild SA227-DC was being operated on a non-scheduled air transport passenger flight from Forrestania to Perth, Western Australia. Close to the top of descent into Perth, the crew experienced a complete loss of pressure in the aircraft's hydraulic system. The crew coordinated with air traffic control for a holding pattern to allow for time to troubleshoot the failure and prepare for an appropriate approach and flapless landing. Ground inspection vehicles were requested to ascertain post-landing if fluid was visibly leaking onto the runway and a tow vehicle was requested to recover the aircraft after landing.

After successfully landing and stopping on the taxiway, the captain was unable to establish contact with the tow vehicle and then decided to continue to taxi to the operator's apron. As the aircraft approached the operator's apron, a slight downhill slope caused an increase in speed. However, when the crew applied the brakes, they were ineffective. In an effort to avoid collision with a hangar, the captain applied reverse thrust. However the aircraft continued to roll forward, the captain shut down the engines and feathered the propellers before impacting the hangar. The aircraft sustained damage to the right-side wingtip and propeller, there were no injuries to crew or passengers.

During the flight, the captain was supervising the cadet-entry first officer's flying when a crack in a hydraulic line led to a hydraulic fluid leak and in-flight failure of the hydraulic system.

Consistent with the first officer's minimal experience, their ability to contribute to the in-flight emergency management was limited, requiring the captain to manage the emergency. The captain was required to take on both the pilot flying and pilot monitoring roles, which reduced their ability to effectively manage the emergency.

The first officer's inexperience limited their ability to contribute to managing the hydraulic system failure. This negatively impacted crew resource management and increased the captain's workload.

After stopping on the taxiway, the captain mistakenly assumed the brakes were functioning. Unable to locate or contact the tow tug, and influenced by self-imposed pressure, they continued the taxi to the apron.

On arrival at the operator's apron, the aircraft had minimal braking capacity and the crew was not able to stop the aircraft. Due to the proximity of the hangar, the captain had limited opportunity to take corrective action and a collision occurred.

Undetected tripped circuit breakers

Occurrences relating to undetected tripped circuit breakers for the last 10 years were sourced from the Australian Aviation Occurrence Database held by the Australian Transport Safety Bureau.

OA2016-05327

On 19 December 2016, during cruise at FL340, the crew of a Fokker 100 detected an electrical system failure and diverted the aircraft to Geraldton. The engineering inspection revealed the Essential AC Bus supply circuit breaker tripped.

OA2017-00392

On 12 January 2017, during a practice forced landing, the flaps failed to retract on an Alpha Aviation Design R2160, and the aircraft was returned to Bankstown. The engineering inspection revealed the flap control circuit breaker had tripped due to hot weather conditions.

OA2017-03066

On 8 July 2017, during approach, the crew of a Cessna 210L received an unsafe landing gear indication and conducted a manual gear extension. The engineering inspection revealed a tripped circuit breaker as the cause of the landing gear not extending.

OA2018-00123

On 21 January 2018, during marine pilot operations, the pilot of a Eurocopter AS350B2 detected an engine fire indication and the helicopter diverted to the Square Reef pontoon. The post-flight inspection revealed a tripped circuit breaker to be the cause of the false engine fire indication.

OA2019-03542

On 11 May 2019, during cruise, a GippsAero GA-8 lost electrical power and the crew conducted a return to Perth. The engineering inspection revealed the alternator circuit breaker tripped.

OA2025-00023

On 3 January 2025, during approach, the crew of a Boeing 737-800 detected an electrical system issue and did not receive a trailing edge flaps indication. The crew conducted a missed approach. The engineering inspection revealed the circuit breaker had tripped.

Flight data acquisition unit related

A search of the Australian Civil Aviation Safety Authority's defect reporting system identified 2 SAAB 340B FDAU related reports.

SAAB 340B, 18 April 2017

On departure through 500 feet electrical smell was apparent in the flight deck. Avionic Smoke master warning illuminated for approximately 5 seconds then went out and stayed out. Smell persisted till landing. On inspection FDAU had a strong burning smell and FDAU lamp on FDEP illuminated. FDAU replaced with serviceable item.

SAAB 340B, 31 May 2024

Acrid smell noticed in flight deck with circuit breaker F19 popped [tripped]. DFDR [flight data recorder] light previously illuminated, extinguished after CB [circuit breaker] popped. Acrid smell also noticeable in avionics rack area. Smell was confirmed to be originating from FDAU, same replaced.

Safety analysis

Introduction

On approach to Lupepau'u Airport, the flight crew identified a hydraulic system issue while conducting their landing checks. The crew elected to return to Fua'amotu Airport due to there being a longer runway and availability of maintenance facilities. After a successful landing, the aircraft lost brake pressure during the taxi to the domestic terminal, exiting the taxiway and impacting a disused refuelling bund, collapsing the right landing gear leg.

This analysis will discuss the hydraulic system issue, and the flight crew's management of it. It will also discuss maintenance issues that became evident during the investigation.

Hydraulic system issue

Loss of brake pressure, taxiway excursion, and ground collision

In normal operation, the braking system was reliant on the electric hydraulic pump providing pressure to the inboard and outboard brake accumulators. As the hydraulic pump was turned off as part of the hydraulic fluid loss abnormal checklist, the only way to provide pressure to both wheel brake accumulators was by manually hand pumping the auxiliary hydraulic system, when individually selected to each brake system. The auxiliary system was utilised during the flight for completing the lowering of the landing gear, however was not used at any stage to maintain pressure in either brake accumulator, or just the outboard brakes accumulator for which they had an indication.

The captain confirmed that brakes were working after landing and continued to taxi to the domestic apron using residual brake pressure stored by the inboard and outboard brake accumulators. Both crewmembers confirmed that they didn't check the hydraulic pressure indication for the outboard brakes during taxi, therefore not identifying the depleting pressure. The abnormal checklist noted that a large number of pumps, and continuous pumping of the auxiliary pump would have been required to maintain normal brake pressure. It could not be determined that if during the taxi, had the crew identified the depleting brake pressure, that sufficient hydraulic pressure could have been restored through use of the auxiliary hydraulic pump to avert a complete loss of braking.

Using the brakes to slow the aircraft during the taxi after landing, rather than reverse thrust likely depleted the remaining hydraulic pressure in the brakes accumulators quickly, resulting in the loss of braking action. With limited effective steering control from the rudder at low speed and no wheel brakes available, directional control was lost and the aircraft exited the taxiway, impacting the disused refuelling installation bund.

Contributing factor

While taxiing to the terminal after landing, the aircraft lost wheel braking and directional control, resulting in the aircraft veering off the apron, impacting a disused refuelling installation bund.

Hydraulic indicators circuit breaker tripped

During the descent, the crew discovered that the indicators for the main hydraulic fluid quantity, main accumulator pressure, and the accumulator pressure for the inboard brakes, were not displaying. The aircraft had previously completed 2 flights on the morning of the accident, with no hydraulic indication issues identified by the flight crew. Had a hydraulic system indication issue been present, it is likely that this would have been identified during the ‘before engine start’ and ‘landing’ normal checklists. It is also likely that a tripped circuit breaker would have been identified and rectified as a result of the ‘before engine start’ checklist on the previous flights and in preparation for the accident flight.

Verification of the main hydraulic fluid quantity, main accumulator pressure, and the operation of the inboard brakes accumulator indicators was confirmed during the post-accident aircraft systems examination by resetting the ‘HYDRAULIC – PR IND / QTY IND’ circuit breaker, bringing the indicators back on-line when power was applied. Therefore, the circuit breaker must have tripped during the flight, resulting in power not being applied to the indicators. However, extended power application to the electrical system during testing did not trip the circuit breaker. At the conclusion of the investigation examination, the reason why the ‘HYDRAULIC – PR IND / QTY IND’ circuit breaker tripped was unable to be determined.

Contributing factor

For reasons that could not be determined, between engines' start and descent, the circuit breaker providing power to the main hydraulic system pressure and quantity indicators, and inboard brakes hydraulic system pressure indicator, had tripped, removing power to those indicators.

Tripped hydraulic indicators circuit breaker not identified

Expectations are based on past experience and other sources of information, and they strongly influence where a person will search for information, what they will search for and their ability to notice and recognise something if it is present (Wickens and McCarley 2008). A substantial body of research has shown that when a person’s attention is focussed on another task, they often do not detect an unexpected object or event, even sometimes when it is salient and the person is looking directly at it (Chabris and Simons 2010). People generally seek information that confirms or supports their hypotheses or beliefs, and either discount or do not seek information that contradicts those hypotheses or beliefs. When the available information is ambiguous, it will generally be interpreted as supporting the hypothesis. This confirmation bias is an inherent aspect of human decision-making and has been demonstrated to occur in a wide range of contexts (Wickens and Hollands 2000).

In this case, while the captain was considering the possibility of an electrical issue due to the nature of the indications presented, the First Officer (FO) considered the issue to be related to a hydraulic leak so probably had little reason to expect that the ‘HYDRAULIC – PR IND / QTY IND’ circuit breaker would have been tripped. Aspects such as expectancy and confirmation bias mean an initial incorrect visual assessment of the circuit breaker position likely occurred and that a second check did not effectively identify and correct the circuit breaker position. Accordingly, it is imperative that crews closely follow the relevant checklists and troubleshooting techniques to their conclusion.

Contributing factor

Likely due to expectancy, the first officer did not visually identify the tripped circuit breaker associated with the hydraulic system indicators while performing the initial hydraulic system troubleshooting.

Misidentified hydraulic system issue

During the landing checklist, the crew correctly identified an anomaly with the hydraulic indications. They discussed the unusual nature of the indications observed and tried several actions to resolve the indications they were seeing. These included selecting the hydraulic pump switch to override (and returning it to normal) and checking the circuit breaker panels. As the crew were unable to validate the indications they were seeing, about 3 minutes after identifying the anomaly, the crew mis-identified the hydraulic system issue and elected to treat it as a hydraulic fluid loss situation. However it is very likely that the hydraulic pressure system was functioning normally, but with power removed from the 3 indicators due to the tripped circuit breaker, it presented as a hydraulic fluid loss situation.

The first item on the abnormal hydraulic fluid checklist was to turn off the hydraulic pump, which in this case removed automatic hydraulic pressure replenishment to an otherwise serviceable system. This ultimately led to hydraulic fluid depletion of the braking system accumulators without manual intervention.

Contributing factor

The crew misidentified that there was a hydraulic leak, and commenced the abnormal checklist for hydraulic fluid loss, which included turning off the hydraulic pump. As a result, no hydraulic pressure was automatically provided to the hydraulic system.

Checklist guidance

When commencing the troubleshooting for the hydraulic system issue, the captain correctly noted that the hydraulic light was not illuminated and tested the central warning panel lights to confirm their correct operation. However, the first officer became overly focussed on the gauge readings, convinced they had lost all hydraulic fluid.

The flight crew's handling of the abnormal checklist was quite informal and frequently interrupted by discussions regarding the various indications and their intentions, rather than reviewing and completing the checklist in its entirety as a 'read and do' procedure. The crew also did not extend the landing gear in conjunction with the hydraulic fluid loss checklist, although they did successfully extend it.

Although covered in their ground school for the SAAB 340B, when interviewed as part of the investigation, the flight crew were not able to describe the aircraft's hydraulic system in any detail. Also, they were not able to recall the functionality of the auxiliary system apart from its ability to lower the landing gear, and what additional services it was able to provide. Without an in-depth knowledge of the aircraft's hydraulic system, had the abnormal checklist been reviewed and actioned in its entirety, the flight crew would likely have had a more complete picture of the limitations of the aircraft's auxiliary hydraulic system, including the likelihood of losing wheel braking action.

Contributing factor

While the crew reviewed sections of the hydraulic loss abnormal checklist during the emergency, they did not read all parts of the checklist. Further, the flight crew only had a basic understanding of the aircraft's hydraulic system. As a result, the flight crew had an incomplete appreciation of the limitations of the inoperative hydraulics system.

Flight crew decision making process

The cockpit voice recorder provided a clear account of the hydraulic system troubleshooting and checklist actions by the flight crew. After some discussion around sections of the abnormal checklist for hydraulic fluid loss, the captain confirmed that they would stop on the runway and get assistance from ground crew to get the aircraft and passengers back to the terminal. They were not able to raise their company personnel on the company radio frequency when they first made the decision, so an opportunity was lost to prepare the engineering and ground staff early enough for an on-runway towing recovery of the aircraft.

The aircraft was close to arriving by the time the company contacted the crew. This led to the engineering support being some time away from being able to recover the aircraft and left a limited opportunity to coordinate ground staff for towing the aircraft. While on approach, the FO asked the captain if they would taxi, and then asked again shortly after landing. The captain was non-committal each time, however no reference was made to the original plan to stop on the runway.

With the captain recognising there was residual brake pressure available after landing, the combination of the FO's suggestions of trying to taxi, and no ground staff available to tow the aircraft, most likely led to the captain's decision to continue to taxi to the terminal. This deviated from the abnormal checklist advice and the company procedure of stopping on the runway and waiting to have the aircraft towed to the terminal.

Contributing factor

During the return to Fua'amotu, the flight crew made the decision to stop on the runway after landing in accordance with the abnormal checklist. During the approach, and after landing, the crew discussed the possibility of taxiing, and after the captain recognised that they had positive control of the aircraft on the ground and without a readily available aircraft tug, continued to taxi to the terminal.

Flight data recorder issue

Flight recorded data loss

Flight data recorders (FDR) have proven themselves over time to provide valuable evidence as to what was occurring at the time of accidents and incidents. This valuable information has gone on to prevent reoccurrence of mishaps.

A successful download of the FDR fitted to this aircraft would have provided multiple flight data parameters for multiple flights, however it had not been recording flight data for about 5 months. There was evidence that power was applied to the FDR, however the unit had not received flight parameter data. Therefore any evidence that may have assisted further with this investigation for future safety enhancement was lost.

Other factor that increased risk

Although power was available to the flight data recorder, it did not record flight data for about 5 months prior to, and including the accident. This limited valuable evidence for this investigation to enhance flight safety.

Flight data acquisition unit failure

After identification that the FDR was not recording flight parameter data, the investigation further examined the aircraft's recording system to identify the reason for the lack of flight data. Under examination, the flight data acquisition unit (FDAU) consistently tripped the 'DATA AQUIS PWR' circuit breaker when power was applied, however did not trip when the FDAU unit was removed. This indicated that the fault was within the FDAU, not the aircraft wiring. However, this did not explain why the tripped circuit breaker issue was not reported by operational crew or resolved appropriately by maintenance personnel. A review of the aircraft's technical log around the time the FDR stopped recording did not identify any recorded events of acrid or burning smells in the cockpit or cabin, which may have indicated that the FDAU had failed internally. After discussions with the aircraft's maintenance engineer, they indicated that this particular circuit breaker had been isolated (collared) during radio troubleshooting as it was understood to be part of the aircraft's high frequency (HF) radio system and that power to the radio needed to be isolated due to ongoing troubleshooting.

Other factor that increased risk

A fault within the flight data acquisition unit resulted in the electrical system circuit breaker for the unit being tripped, removing power from the unit. This resulted in flight data not being sent to or recorded by the flight data recorder. The fault identified by the tripped circuit breaker, went unrectified as it was misdiagnosed as an issue with the aircraft's high frequency radio system.

Undocumented maintenance

Undocumented troubleshooting

There was no maintenance record of the FDAU having become unserviceable, or a collar being fitted to its circuit breaker. As a result of this action, the flight recording system had been unserviceable since 11 July 2023 and the accident flight was not recorded on the FDR. Even though there was evidence of earlier troubleshooting, no record had been made in the aircraft's technical log about the power isolation by circuit breaker collaring on the HF radio system or otherwise. It was also identified that this had not been raised as an entry on the minimum equipment list for the aircraft either. This undocumented maintenance limited the opportunity to further troubleshoot the system and potentially identify that the circuit breaker issue was related to the FDR.

Other factor that increased risk

While troubleshooting an issue with the aircraft's communication system, a maintenance engineer inadvertently secured the tripped circuit breaker for the flight data acquisition unit in the tripped position. However, no maintenance action had been recorded, limiting the opportunity to recognise that the flight data recorder was not recording.

Under water locator beacon not fitted

The most recent 2-yearly avionics maintenance check of the aircraft, mis-identified that the underwater locator beacon (ULB) was missing from the FDR. The Australian Transport Safety Bureau (ATSB) examination of the CVR identified that the ULB and mounting bracket was missing from the CVR, however a ULB and mounting bracket was fitted to the FDR.

Without these devices fitted to either the CVR and/or FDR, there is limited ability for the wreckage and recorders to be located and recovered. As the majority of the flying conducted with A3-PUA was over water, this enhanced the importance of the ULB's installation and proper function. Furthermore, without the ULB fitment, post-accident location and recovery in the event of an accident at sea would be impaired as well as precluding the ability to extract vital data from the CVR, losing the potential to identify safety issues.

Other factor that increased risk

Although the cockpit voice recorder was functioning correctly, the underwater locator beacon and associated mounting bracket had been removed from the cockpit voice recorder at least 6 months prior to the accident. This reduced the likelihood of locating the cockpit voice recorder in the event of an accident at sea, limiting valuable evidence for enhancing flight safety.

Maintenance procedures

During the investigation, 2 defects were identified while downloading data from the CVR and FDR, and examining the reason for the FDR not recording the flight parameters. These were the missing ULB, and the subsequent identification that a FDAU was tripping the 'DATA AQUIS PWR' circuit breaker. These defects, including the collared circuit breaker were not recorded in the aircraft technical log or minimum equipment list (MEL). Although these undocumented defects came to light during the investigation, there was no evidence to indicate that this was a regular occurrence. The aircraft's technical log and MEL provided ample evidence that defects were regularly being identified, recorded and rectified through entries in the technical log, and where appropriate, deferred to the MEL.

Other finding

Two maintenance defects identified during the investigation were not recorded in the aircraft's technical logbook, or appropriately actioned when identified. The investigation considered that it may be a broader issue, however there was considerable evidence to indicate that defect rectification was regularly being conducted and recorded correctly.

Chief executive officer presence on the flight deck

Travelling on the flight deck and being stationed in the observation seat was specifically restricted by the operator to operational crew and company employees. Access to use the observation seat was at the discretion of the captain for that flight. In this instance, the captain approved the chief executive officer (CEO) to occupy the observation seat for the flight to Vava'u.

The CEO was briefed on the hydraulic system issue by the flight crew after the flight crew had initially troubleshot the issue and commenced their return to Fua'amotu. The CEO did not offer or provide input into the decision making of the flight crew and remained silent while the crew worked through the issue.

From the evidence available on the CVR and through interviews with the flight crew and CEO, there was no evidence available during the investigation to indicate that the CEO influenced, or attempted to influence the decision making of the flight crew.

Other finding

While the chief executive officer was seated on the flight deck in an observation seat, there was no evidence to indicate that they influenced the crew's decision making during the accident flight.

Findings

The investigation report findings focus on safety factors (that is, events and conditions that increase risk). Safety factors include 'contributing factors' and 'other factors that increased risk' (that is, factors that did not meet the definition of a contributing factor for this occurrence but were still considered important to include in the report for the purpose of increasing awareness and enhancing safety). In addition 'other findings' may be included to provide important information about topics other than safety factors.

These findings should not be read as apportioning blame or liability to any particular organisation or individual.

From the evidence available, the following findings are made with respect the loss of control during taxi and ground collision event involving a SAAB 340B, registered A3-PUA, at Fua'amotu International Airport, Tonga, on 08 December 2023.

Contributing factors

- While taxiing to the terminal after landing, the aircraft lost wheel braking and directional control, resulting in the aircraft veering off the apron, impacting a disused refuelling installation bund.
- For reasons that could not be determined, between engines' start and descent, the circuit breaker providing power to the main hydraulic system pressure and quantity indicators, and inboard brakes hydraulic system pressure indicator, had tripped, removing power to those indicators.
- Likely due to expectancy, the first officer did not visually identify the tripped circuit breaker associated with the hydraulic system indicators while performing the initial hydraulic system troubleshooting.
- The crew misidentified that there was a hydraulic leak, and commenced the abnormal checklist for hydraulic fluid loss, which included turning off the hydraulic pump. As a result, no hydraulic pressure was automatically provided to the hydraulic system.
- While the crew reviewed sections of the hydraulic loss abnormal checklist during the emergency, they did not read all parts of the checklist. Further, the flight crew only had a basic understanding of the aircraft's hydraulic system. As a result, the flight crew had an incomplete appreciation of the limitations of the inoperative hydraulics system.
- During the return to Fua'amotu, the flight crew made the decision to stop on the runway after landing in accordance with the abnormal checklist. During the approach, and after landing, the crew discussed the possibility of taxiing, and after the captain recognised that they had positive control of the aircraft on the ground and without a readily available aircraft tug, continued to taxi to the terminal.

Other factors that increased risk

- Although power was available to the flight data recorder, it did not record flight data for about 5 months prior to, and including the accident. This limited valuable evidence for this investigation to enhance flight safety.

- A fault within the flight data acquisition unit resulted in the electrical system circuit breaker for the unit being tripped, removing power from the unit. This resulted in flight data not being sent to or recorded by the flight data recorder. The fault identified by the tripped circuit breaker, went unrectified as it was misdiagnosed as an issue with the aircraft's high frequency radio system.
- While troubleshooting an issue with the aircraft's communication system, a maintenance engineer inadvertently secured the tripped circuit breaker for the data acquisition unit in the tripped position. However, no maintenance action had been recorded, limiting the opportunity to recognise that the flight data recorder was not recording.
- Although the cockpit voice recorder was functioning correctly, the underwater locator beacon and associated mounting bracket had been removed from the cockpit voice recorder at least 5 months prior to the accident. This reduced the likelihood of locating the cockpit voice recorder in the event of an accident at sea, limiting valuable evidence for enhancing flight safety.

Other findings

- Two maintenance defects identified during the investigation were not recorded in the aircraft's technical logbook, or appropriately actioned when identified. The investigation considered that it may be a broader issue, however there was considerable evidence to indicate that defect rectification was regularly being conducted and recorded correctly.
- While the chief executive officer was seated on the flight deck in an observation seat, there was no evidence to indicate that they influenced the crew's decision making during the accident flight.

Safety issues and actions

Proactive safety action taken by Lulutai Airlines

Lulutai Airlines identified several key observations and potential corrective actions from the preliminary report for this investigation that could be drawn from the available information provided. On 11 November 2024, the operator provided Tonga Civil Aviation Office (TCAO) with a remedial action plan.

Their response stated that a phased approach is proposed. This approach balances the immediate need for corrective action with the practicalities of implementation, ensuring that risks are effectively mitigated while fostering a foundation for longer-term safety improvements.

They stated that the accident provided learnings for all the operator's staff, of the critical importance of proactive monitoring, rigorous maintenance, and strict adherence to established policies and procedures across all aircraft systems. To mitigate the recurrence of similar events and ensure the highest standards of operational safety, the following strategic recommendations were proposed:

- The operator should institute robust procedures to ensure the systematic and regular inspection of critical aircraft systems. This includes communication, navigation, propulsion, and structural components. Priority should be given to identifying potential vulnerabilities, such as wiring issues, external interference, wear and tear, and component malfunctions.
- A fleet-wide Inspection has been initiated as an immediate measure to address the issues identified. This action is supplementary to the broader remedial action plan detailed in this report, which provides a medium-term framework for addressing systemic concerns.
- The airline should adopt a structured approach to proactively identify and resolve potential issues before they impact operations. This includes routine testing of essential systems such as the cockpit voice recorder (CVR), cockpit area microphone, and other critical equipment. Incorporating these activities into the preventative maintenance program will enhance reliability and system integrity.
- As part of its ongoing commitment to effective safety management system implementation, Lulutai Airlines has developed a risk register. This document catalogues potential risks arising from the issues identified in the preliminary report and outlines mitigation strategies to manage them effectively. This risk assessment will be incorporated as part of Lulutai Airlines' overall enterprise risk management (ERM) register.
- Continuous monitoring and diligent follow-up are essential to confirm adherence to these procedures at all operational levels. Embedding these practices into standard operating procedures and the preventative maintenance program will foster accountability, conformance, and operational discipline. To reinforce this, the identified remedial action items will be incorporated into the audit programme, providing a mechanism for ongoing evaluation, effective implementation of actions, and ensuring accountability among responsible personnel.

- By integrating these measures into its operational framework, Lulutai Airlines will not only strengthen its safety culture but also reinforce a commitment to compliance and excellence. Such initiatives are critical to maintaining safety, preventing future incidents, and safeguarding the airline's operational integrity.

The operator concluded that implementing these recommendations will enable Lulutai Airlines to proactively address safety concerns, uphold operational reliability, and reaffirm its dedication to industry-leading standards of safety and quality.

On 27 January 2025, Lulutai Airlines provided an update to their remedial action plan detailing steps taken, and that action items are on-going. They considered their operational and maintenance procedures to be adequate, however were planning to imbed lessons learnt into procedures and expanding maintenance procedures, including the CVR microphones and underwater locator beacon testing. They also intend to strengthen and foster a culture of continuous safety improvement.

Tonga Civil Aviation Office Chief Investigator comment

The TCAO Chief Investigator acknowledges Lulutai Airlines remedial action plan and looks forward to receiving on-going safety action as they address the identified areas of proactive improvement within their systems.

General details

Occurrence details

Date and time:	8 December 2023 – 1400 Tonga Standard Time	
Occurrence class:	Accident	
Occurrence categories:	Taxiing collision	
Location:	Fua'amotu International Airport, Tongatapu, Tonga	
	Latitude: 21.2434° S	Longitude: 175.1375° W

Aircraft details

Manufacturer and model:	SAAB 340B	
Registration:	A3-PUA	
Operator:	Lulutai Airlines Limited	
Serial number:	408	
Type of operation:	Part 121 air transport operations	
Activity:	Commercial air transport – Scheduled – Domestic	
Departure:	Fua'amotu, Tongatapu, Tonga	
Destination:	Lupepau'u Airport, Vava'u, Tonga	
Actual destination:	Fua'amotu, Tongatapu, Tonga	
Persons on board:	Crew – 3	Passengers – 35
Injuries:	Crew – 0	Passengers – 0
Aircraft damage:	Substantial	

Glossary

AIP	Aeronautical information publication
AOM	Aircraft operations manual
ATC	Air traffic control
ATSB	Australian Transport Safety Bureau
CAM	Cockpit area microphone
CEO	Chief executive officer
CI	Tonga Chief investigator
CRM	Crew resource management
CTSM	Crew training and standards manual
CVR	Cockpit voice recorder
CWP	Central warning panel
FA	Flight attendant
FDAU	Flight data acquisition unit
FDEP	Flight data entry panel
FDR	Flight data recorder
FO	First officer
FOM	Flight operations manual
HF	High Frequency (radio)
HMAF	His Majesty's Armed Forces
HYDR	Hydraulic
LAME	Licenced aircraft maintenance engineer
MEL	Minimum equipment list
MMEL	Master minimum equipment list
MMM	Maintenance management manual
OCA	Operational competency assessment
QRH	Quick reference handbook
RFS	Rescue and Fire Service
SOP	Standard operating procedure
TCAO	Tonga Civil Aviation Office
ULB	Underwater locator beacon

Sources and submissions

Sources of information

The sources of information during the investigation included:

- the flight crew for the accident flight
- the licenced aircraft maintenance engineer for A3-PUA
- Lulutai Airlines
- Tonga Civil Aviation Office
- Tonga Airports Limited
- SAAB
- cockpit voice recorder and flight data recorder
- accident witnesses
- photographs taken on the day of the accident

References

Chabris, C., & Simons, D. 2010, *The invisible gorilla and other ways our intuition deceives us*, HarperCollins, Hammersmith UK.

Wickens, CD & Hollands, JG, 2000, *Engineering psychology and human performance*, 3rd edition, Prentice-Hall International, Upper Saddle River, NJ.

Wickens, CD & McCarley, JS 2008, *Applied attention theory*, CRC Press, Boca Raton, FL.

Submissions

Under Annex 13, section 6.3, the investigation authority may provide a draft report, on a confidential basis, to any person it considers appropriate. That section allows a person receiving a draft report to make submissions about the draft report.

A draft of this report was provided to the following directly involved parties:

- Captain and first officer of the occurrence flight
- the LAME for A3-PUA
- Lulutai Airlines
- Tonga Civil Aviation Office
- Swedish Accident Investigation Authority.

A submission was received from Lulutai Airlines.

The submission was reviewed and, where considered appropriate, the text of the report was amended accordingly.

Appendices

Appendix A: Lulutai Airlines Abnormal checklist - HYDR light on

LULUTAI WINGS OF TONGA

ABNORMAL CHECKLIST
Quick Reference Handbook

HYDR light on

HYDR light on

*1. HYDR PUMP switch .... OFF
*2. Check HYDRAULIC INDICATORS.

EMER and MAIN pressure are both LOW:

CAUTION: Leave flaps in present position.

SPEED BELOW 200 KIAS:

*3. LANDING GEAR handle .... DOWN
*4. EMERG LDG handle .... PULL
5. LAND at nearest suitable airport.
6. Apply HYDRAULIC FLUID LOSS procedure for Flaps considerations and Brake operation. **Page A30**
7. If Landing Gear not down and locked Apply EMERGENCY LANDING procedure. **Page E22**
8. End of procedure.

EMER pressure LOW and MAIN pressure NORMAL:

3. Apply HYDRAULIC FLUID LOSS procedure for Landing Gear, Flaps and Brake operation. **Page A30**
   – Follow procedure as for HYD MAIN PRESS LOW.
4. End of procedure.

EMER press NORMAL and MAIN pressure LOW:

HYD QTY DECREASING OR BELOW RED radial line:

3. Apply HYDRAULIC FLUID LOSS procedure for Landing Gears, Flaps and Brake operation. **Page A30**
4. End of procedure.

HYD QTY NORMAL:

3. HYDR PUMP switch .... OVRD then OFF
   – Place the switch momentarily into OVRD position and check for increase in MAIN pressure.

NO INCREASE in MAIN pressure when in OVRD:

4. Apply HYDRAULIC FLUID LOSS procedure for Landing Gears, Flaps and Brake operation. **Page A30**
5. End of procedure.

INCREASE in MAIN pressure when in OVRD:

4. Switch between OVRD and OFF as required to maintain pressure when operating hydraulic systems.
5. End of procedure.

EMER and MAIN pressure are both NORMAL:

–This indicates high temperature in the main reservoir.

3. Switch between OVRD and OFF as required to maintain pressure when required for Landing Gear, Flaps and Brake operation.

BEFORE LANDING

4. HYDR PUMP switch .... OVRD
5. End of procedure.

- The light will come on if low hydraulic pressure in any of the hydraulic accumulators or high fluid temp in the main reservoir.
- Maximum speed for gear normal and emergency extension is 200 KIAS.
- With HYD QTY NORMAL and NO INCREASE in MAIN Pressure when in OVRD indicates a faulty Electrical pump, this will require Manual Extension of the Gear with the Handpump. This is reflected under HYD FLUID LOSS checklist.

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Abnormal Checklist
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Version 2.0, Rev 0: 01 Jun 2022
Approved by FOM

Appendix B: Lulutai Airlines Abnormal checklist - hydraulic fluid loss

LULUTAI
WINGS OF TONGA

ABNORMAL CHECKLIST
Quick Reference Handbook

HYDRAULIC FLUID LOSS

*1. HYDR PUMP switch .... OFF

NOTE: A large number of handpump strokes with gradual increase in resistance is required to obtain desired pressure.

Landing gear extension

2. AIRSPEED .... MAX 200 KIAS

◆ **EITHER HYD QTY OR HYD MAIN pressure LOW.**

3. LANDING GEAR HANDLE .... DOWN
4. HAND PUMP SELECTOR .... FLAPS LDG GEAR
   – Operate hand pump until the Landing Gear is down and locked.

◇ **HAND PUMP extension successful:**

5. BRAKE PRESSURE .... CHECK

◆ **BOTH HYD QTY AND HYD MAIN pressure LOW**
◇ **OR HAND PUMP extension NOT successful:**

3. EMERG LDG handle .... PULL
4. LANDING GEAR HANDLE .... DOWN
5. BRAKE PRESSURE .... CHECK

– If Emergency Extension NOT successful: Proceed with EMERGENCY LANDING CHECKLIST **Page E22**

If brake pressure needs to be increased

CAUTION: If HYD QTY loss was accompanied by an excessive pressure loss in INB or OUTB BRK accumulator, do not use hand pump to increase pressure in that accumulator. Pressure loss in a BRK accumulator is always accompanied by pressure loss in the MAIN accumulator.

1. HAND PUMP SELECTOR .... SET TO DESIRED BRAKE SYSTEM
   – Operate Hand Pump to increase brake accumulator pressure.

NOTE: A fully charged brake system will normally be sufficient to stop the aircraft using normal braking technique. Braking with anti–skid system ON normally consumes less hydraulic fluid than with anti–skid system OFF.

◆ **BOTH brake systems pressurized:**

2. Use normal braking technique.
   – Avoid excessive cycling of the brakes.

◆ **ONE brake system pressurized:**

2. Increase V_{REF} by Malfunction increment (Mi) and ice increment i.a.
   – Consider increased landing distance.

Landing Flap	ICE ACC	ICE INCR F20 / 35	Mi F20 / 35	Mi / Wi	LDF F20 / 35
0	No	–	+20 / +25	+Wi	1.42* / 1.42*
	Yes	+10	+20 / +25	+Wi	1.60 */ 1.80*
20	No	–	–	+Wi	1.32
	Yes	+10	–	+Wi	1.45
35	No	–	–	+Wi	1.32
	Yes	+10	–	+Wi	1.45

* Assumes use of full reverse.

3. Use normal braking technique.
   – Avoid excessive cycling of brakes.

Continued...

HYDRAULIC FLUID LOSS

A large number of hand pump strokes are required for flap and landing gear operation.

Stroke resistance characteristics vary from very light to rather heavy.

Position of handpump selector is important. Normally center for gear and flaps and at the outer end (left/right) for inboard/outboard brakes.Small adjustments to these positions might be necessary to achieve enough pressure.

A large number of hand pump strokes and continuous pumping is required to achieve and maintain enough brake pressure.

Normal action with a faulty hydraulic pump is to tow the aircraft on ground. It is a challenging task to taxi on ground with just the handpump as pressure source.

Direct entry into this procedure is when Hydraulic Quantity is low. The majority of Hydraulic fault related procedures referres to this procedure for Landing Gear, Flaps and Brake operation.

Even though emergency extension does not require the Landing Gear handle to be selected down it shall be selected down for the obvious reason of agreeing with the Landing Gear position. It is also required for anti–skid function.

Maximum speed for gear normal or emergency extension is 200 KIAS.

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ABNORMAL CHECKLIST
Quick Reference Handbook

LULUTAI WINGS OF TONGA

If brake pressure needs to be increased

Continued...

NO brake system pressurized:

2. Increase V_{REF} by Malfunction increment (Mi) and ice increment i.a.
   – Consider increased landing distance.

Landing Flap	ICE ACC	ICE INCR F20 / 35	Mi F20 / 35	Mi / Wi	LDF F20 / 35
0	No	–	+20 / +25	+Wi	2.90 / 3.00
	Yes	+10	+20 / +25	+Wi	3.10 / 3.25
20	No	–	–	+Wi	2.40
	Yes	+10	–	+Wi	2.60
35	No	–	–	+Wi	2.25
	Yes	+10	–	+Wi	2.35

NOTE: The LDF assumes use of full reverse.

3. Use reverse thrust as required for stopping.

Flaps operation

NOTE: If HYD MAIN Press was NORMAL before Landing Gear extension, follow procedure below as for HYD QTY OR HYD MAIN press LOW.

EITHER HYD QTY OR HYD MAIN pressure LOW:

1. FLAP HANDLE .... SET TO DESIRED POS.
2. HAND PUMP SELECTOR .... FLAPS LDG GR
   – Operate Hand Pump until desired flap setting is obtained.

BOTH HYD QTY AND HYD MAIN pressure LOW.

– Do not operate the flaps, land with present flaps setting.

1. Increase V_{REF} by Malfunction increment (Mi) and ice increment i.a.
   – Consider increased landing distance.

Landing Flap	ICE ACC	ICE INCR F20 / 35	Mi F20 / 35	Mi / Wi	LDF F20 / 35
0	No	–	+20 / +25	+Wi	1.30 / 1.35
	Yes	+10	+20 / +25	+Wi	1.45 / 1.50
7	No	–	+10 / +15	+Wi	1.15 / 1.30
	Yes	+10	+10 / +15	+Wi	1.35 / 1.40
15	No	–	+5 / +10	+Wi	– / 1.15
	Yes	+10	+5 / +10	+Wi	1.30 / 1.35

2. GPWS FLAP/TAWS FLAP switch .... OVRD

Before landing

– If either HYD QTY or HYD MAIN pressure low consider to increase HYD MAIN pressure before landing, by use of the HAND PUMP, to assure Nose wheel steering function during roll out. If hydraulic pressure is lost, nose wheel steering will be inoperative.

Continued...

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LULUTAI
WINGS OF TONGA

ABNORMAL CHECKLIST
Quick Reference Handbook

After landing

Continued...

WARNING: Do not taxi with a faulty hydraulic pump. Once the aircraft has come to a stop after landing, shut down engines with Fire Handles to prevent uncontrolled forward thrust. Tow the aircraft to a safe parking. Ensure that AUTOCOARSEN is selected to OFF prior to shutting down the engines.

NOTE: During taxiing with a non-functioning hydraulic pump the hydraulic functions will be abruptly lost when hydraulic accumulator pressure falls below approximately 1650 psi.

End of procedure

HYDRAULIC FLUID LOSS

Applicable to aircraft with Dowty propellers

At engine shut down and if the Condition Levers are moved rapidly to START position, there will be a momentary burst of forward power. This will cause a yaw if one engine is shut down at a time or cause the aircraft to move forward if parked on a slippery area or if the brakes are inoperative. A smooth feathering will be accomplished by monitoring the PROP OIL pressure, which initially rises and then drops when CL is about half way between MIN and START. At pressure rise, hold the CL for a few seconds then move slowly into START. This can be avoided by leaving the CL's at the MIN position and shutting down the engines with the fire handle.

Applicable to aircraft with Hamilton Sundstrand propellers

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