PAPUA NEW GUINEA

ACCIDENT INVESTIGATION COMMISSION

FINAL REPORT

AIC 15-2029

Heli Solutions

Bell Helicopters B407

In-flight External Load Jettison

Mt. Strong, Morobe Province

PAPUA NEW GUINEA

2 May 2015

About the AIC

The Accident Investigation Commission (AIC) is an independent statutory agency within Papua New Guinea (PNG). The AIC is governed by a Commission and is entirely separate from the judiciary, transport regulators, policy makers and service providers. The AIC's function is to improve safety and public confidence in the aviation mode of transport through excellence in: independent investigation of aviation accidents and other safety occurrences within the aviation system; safety data recording and analysis; and fostering safety awareness, knowledge and action.

The AIC is responsible for investigating accidents and other transport safety matters involving civil aviation, in PNG, as well as participating in overseas investigations involving PNG registered aircraft. A primary concern is the safety of commercial transport, with particular regard to fare-paying passenger operations.

The AIC performs its functions in accordance with the provisions of the *PNG Civil Aviation Act 2000 (As Amended)*, and the *Commissions of Inquiry Act 1951*, and in accordance with *Annex 13* to the Convention on International Civil Aviation.

The object of a safety investigation is to identify and reduce safety-related risk. AIC investigations determine and communicate the safety factors related to the transport safety matter being investigated.

It is not a function of the AIC to apportion blame or determine liability. At the same time, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the AIC endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why it happened, in a fair and unbiased manner.

About this report

Decisions regarding whether to conduct an investigation, and the scope of an investigation, were based on many factors, including the level of safety benefit likely to be obtained from the investigation. This occurrence was not formally notified to the AIC at the time of the occurrence. A subsequent administrative investigation commissioned by the then AIC Board on 11 May 2015 was not conducted in accordance with *Annex 13* to the *Convention on International Civil Aviation* and was not filed as an AIC occurrence investigation.

In January 2018, the new AIC Board directed that an investigation into this serious incident was to be conducted in accordance with legislated mandates and *ICAO Annex 13*. This *Final Report* has been produced in accordance with the *PNG Civil Aviation Act 2000 (as amended)*, ICAO *Annex 13*, and the *PNG Accident Investigation Commission's Policy and Procedures*.

In-flight release of external load

Occurrence details

On 2 May 2015, at about 00:20 UTC[1] (10:20 local time) a Bell Helicopters 407 helicopter (B407), registered P2-HSL, owned and operated by Heli Solutions was in the circuit area, at about 11,700 ft, at Mt. Strong (07°58'10" S, 146°56'40" E), Morobe Province. During the approach to the helipad, with an external load of two diesel fuel drums (about 230 kg), the helicopter unexpectedly entered a sudden un-commanded high rate of descent. The pilot stated that the helicopter's speed was around 30 kts when he experienced the un-commanded descent.

The pilot had completed a flight carrying passengers to Mt. Strong immediately prior to the incident flight. According to the pilot, the conditions appeared suitable for the external load flight. He stated that when the helicopter started to descend his first reaction was to raise the collective to try an arrest the descent, but that action had no effect so he immediately jettisoned the load[2]. The pilot reported that following the load release, he saw a caution 'Check Instrument' light illuminated on the annunciator panel and noticed an 'E' light (signifying a gas producer (Ng) turbine exceedance).

The pilot stated that he landed the helicopter safely at Mt. Strong and performed a visual external check of the helicopter with the engine running and rotors turning. After securing the external load equipment, the pilot flew the helicopter to Bereina and refuelled it with the engine running and rotors turning. The pilot picked up one of the loadmasters and positioned the helicopter from Bereina to the operator's maintenance facility at Jacksons Airport, Port Moresby (See figure 1). Following engine shut down, the Ng exceedance was confirmed by engineering personnel. The engine was removed and sent to a Rolls-Royce approved overhaul facility for inspection and repair as appropriate.

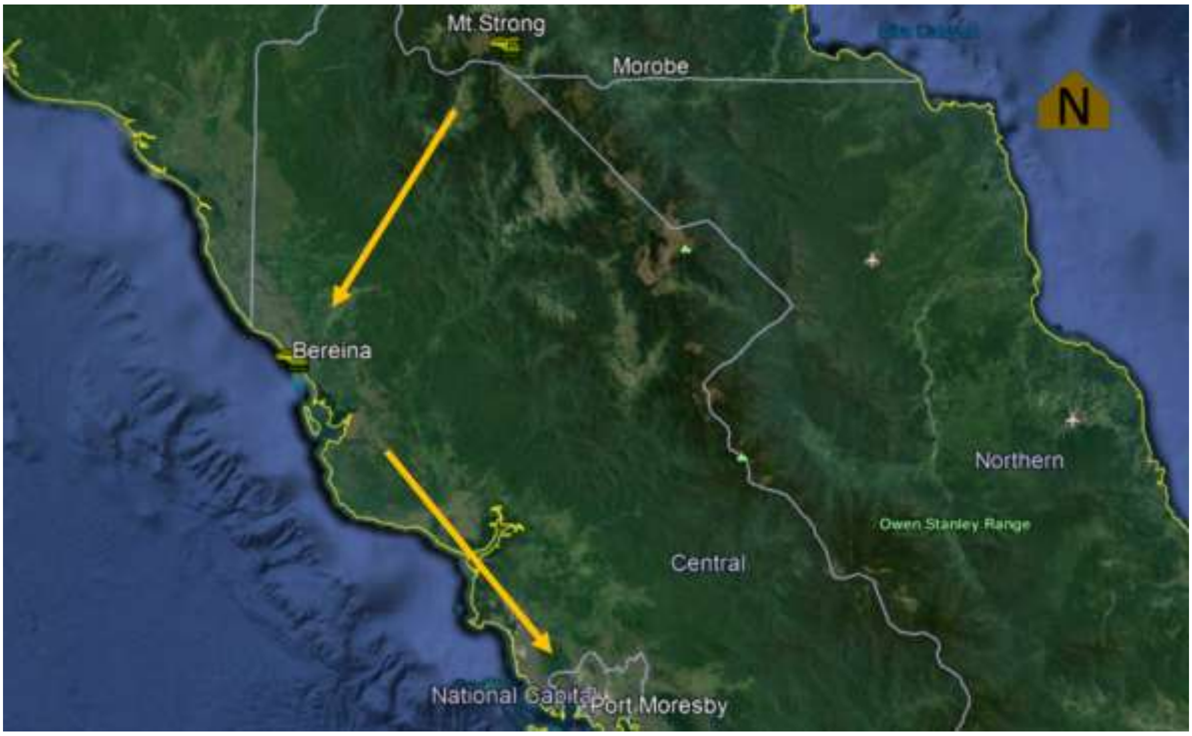

Figure 1: P2-HSL flight after occurrence

[1] The 24-hour clock, in Coordinated Universal Time (UTC), is used in this report to describe the local time as specific events occurred. Local time in the area of the accident, Papua New Guinea Time (Pacific/Port Moresby Time) is UTC + 10 hours.
[2] *ICAO Annex 13 Attachment C* lists external load release as a serious incident.

Mt. Strong

Mount Strong, in the Morobe Province is 11,597 ft above mean sea level and is located along the Chapman Ranges. There is a telecommunication tower located in the area and helicopter operations are usually conducted to the helipad adjacent to the telecommunication tower to drop technical personnel, diesel and maintenance equipment.

Weather

In a written statement dated 4 May 2015, the pilot reported active cumulonimbus cells 'within the vicinity of the helipad', and rain showers beginning to fall around the area as he was approaching Mt. Strong. He also reported that the air temperature was 10°C, with wind noted before the occurrence from the southwest at 20 knots, and after the occurrence from the north-northwest, but he did not report the wind strength.

The pilot

The pilot was highly experienced flying helicopters including the B407 within Papua New Guinea. He had flown in some of PNG's most challenging conditions for more than 30 years. He held a current pilot licence and medical certificate at the time of the serious incident.

During the AIC interview on 26 March 2018, the pilot stated that his decision not to shut down at Mt. Strong was based on the following considerations: Mt. Strong was remote and isolated; he would not have been able to start the helicopter's engine once it was shut down; the weather that was moving in would have closed him in; and there was a lack of mobile phone coverage.

Following the landing at Mt. Strong, the pilot did not follow the corrective action required by the *Aircraft Flight Manual* to determine the cause of the *CHK INSTR* light illumination which would have indicated the magnitude of the exceedance. The flight manual states to press the *'Instrument Check'* button. The pilot stated that he believed the cause of the *CHK INSTR* light illumination could only be determined after shutting the helicopter's engine down.

On arrival at Bereina, there was adequate phone coverage, but the pilot was adamant that similar issues to those considered at Mt. Strong, would have been faced if the helicopter's engine was shut down at Bereina. Therefore, he refuelled the helicopter with the engine running and the rotor turning, picked up his load master and continued to Port Moresby where he then shut the engine down.

The pilot did not notify the PNG Air Services Limited Flight Service Unit about the occurrence. He also did not notify the Civil Aviation Safety Authority of PNG (CASA) as required under *Civil Aviation Rules (CAR) Part 12*. A report was sent to CASA on a CA005 form on 7 May 2015. That was subsequent to an email from the Heli Solutions Quality Officer telling him that he was grounded until he provided a notification.

The pilot was not a full-time employee of the operator, but rather an employee on a part-time contract. The pilot was a full-time employee of the PNG Government Public Service, employed as the Chief Executive Officer (CEO) of the PNG Accident Investigation Commission. The laws governing his employment with the PNG Government did not allow for him to engage in an aviation business or corporate organisation that operates air services or provides air services in Papua New Guinea (Refer to Organisation Section).

Aircraft performance

The *hover ceiling out of ground effect* (HOGE) chart used by the pilot for the performance calculation references take-off power at 100% engine RPM, at skid height at 40 ft above ground. A 10°C outside air temperature at 11,000 ft pressure altitude was used by the pilot for the performance calculation.

The application of take-off power would permit a maximum gross weight hover at 4,400 lbs. The gross weight reported on arrival at Mt. Strong was 4,381 lbs which was 19 lbs under HOGE performance at the altitude and temperature reported.

According to the *Bell Helicopter B407 Flight Manual* (extract below), when the *CHECK INSTR* light illuminates, the pilot is required to identify which parameter was exceeded.

The Ng cockpit instrument data is electronically received through the FADEC[3] unit which is transmitted by the Ng sensor. The Ng instrument will illuminate an 'E' light if that instrument detects that an allowable parameter was exceeded. The FADEC system is designed to notify operators of faults and exceedances as they occur or at shutdown/pre-start-up through annunciator displays on the caution, warning and advisory panel, sufficient to advise operators when FADEC system maintenance actions are required.

An *'E'* light on the cockpit instrument (See figure 2) indicates that the helicopter's Ng sensor has detected an exceedance of its parameter requiring the pilot to reduce engine power and press the *INSTR CHK* button. Pressing that button displays the magnitude of the exceedance.

CHECK INSTR	TRQ, MGT, or NG is about to or has detected an exceedance. Flashing LCD trend arc and digital display indicates impending exceedance. Letter E in digital display indicates an exceedance has occurred.	Reduce engine power if possible. Press INSTR CHK button to display magnitude of exceedance. Refer to BHT-407-MD-1.

Figure 2: Extracts from flight manual in relation to Ng exceedance

3 FADEC: Full authority digital engine control.

BHT-407-MD-1 MANUFACTURER'S DATA

1-21-B. GAS PRODUCER GAUGE (N_G)

The gas producer (N_G) gauge displays engine gas producer speed in percent of rated RPM (Table 1-5).

An N_G Speed Pickup mounted in the engine gearbox provides two separate signals to the ECU. One signal is the primary driver of the N_G gauge and is also a secondary signal for the ECU. The second signal is the primary input to the ECU. The primary signal to the gauge will be passed through the ECU, even when the ECU is not powered.

When the FADEC system is in MANUAL mode, the N_G gauge operates as a trigger device for the ENGINE OUT horn and light when N_G drops below 55%. In the event of a power loss to the N_G indicator while operating in MANUAL mode, the failure mode will provide continuous ignition regardless of N_G speed, but the ENGINE OUT light and horn will not be activated when N_G drops below 55%.

Table 1-5: GAS PRODUCER GAUGE (N_G) Exceedance Monitoring

N_G%	Indication	Exceedance
105.1 to 106%	Trend ARC starts flashing immediately. Stops flashing after 10 seconds.	Recorded after 10 seconds.
Above 106.1%	Trend ARC begins flashing prior to reaching 106.1%, as described above. Stops flashing at 106.1% and above.	Recorded immediately.

Figure 3: BHT-407-MD-1 extract

Following that action, the pilot is required to refer to the BHT-407-MD-1 (*Bell Helicopter 407 Manufacturer's Data-1 Manual*). That manual identifies that maintenance actions are required to be carried out in accordance with the *Aircraft Maintenance Manual* (*BHT-407-MM*) and *Rolls-Royce 250-C47B Operations and Maintenance Manual*.

The pilot performed the actions identified in the *Flight Manual* following the subsequent landing and shutdown at Port Moresby. The *CA005* report form dated 7 May 2015 notified CASA that two gas producer limits had been exceeded: The first, for more than 10 seconds between 105.1 to 106.0 %, and the second above 106.0 % where the upper Ng value was recorded at 106.2%.

Both types of gas producer (Ng) exceedance monitoring parameters are described in the *Bell Helicopter 407 Flight Manual* and the *Bell Helicopter 407 Manufacturers Data Manual* (See figure 3).

A transient limit of up to 10 seconds between 105.1 to 106% does not record an exceedance, but the flight manual states in the *Limitations* section (page 1-13) that intentional use of any power transient is prohibited.

The extract from the *Rolls-Royce M250-C47B Operation and Maintenance Manual* (below) shows a 0.5% higher value for over 10 second transient N1 (gas producer) (106.5%), and 0.4% higher than the 106.1% value in the *BHT-407-Flight Manual* and *BHT-407-Maintenance Data-1 Manuals*.

The values are inconsistent between BHT and Rolls-Royce. If the exceedance recorded in the *BH-407-Flight Manual* is 106.2% for example, reference to the Rolls-Royce manual does not require engine removal until a value of 106.5% is reached.

EXPORT CONTROLLED **Rolls-Royce**

M250-C47B OPERATION AND MAINTENANCE

TECHNICAL ASPECTS ARE FAA APPROVED TEMPORARY REVISION E2R20-72-2

(e) After ground run, remove and inspect filter. If filter shows not accumulated debris, release aircraft for flight. During the next 30 hours of operation, check engine oil filter at approximately 10-hour intervals to determine if additional debris has accumulated in the filter.

(12) Engine Operated With No Oil Pressure

Engines operated for more than 30 seconds without oil pressure must be removed and sent to an Rolls-Royce authorized facility for disassembly and inspection as defined by the M250-C47B Engine Overhaul Manual, Publication CSP22001.

(13) Engine Overspeed

For a N_2 exceedance between 102.1% and 113.3% for greater than 15 seconds, remove turbine for inspection at Overhaul facility.

For a N_2 exceedance of Maximum Transient limit 113.3%, remove turbine for inspection at Overhaul facility. If power turbine speed exceeds 113.3%, replacement of 3rd and 4th stage turbine wheels is required and inspection of accessory gearbox is required.

For a complete loss of output shaft load, remove turbine and accessory gearbox for inspection at Overhaul facility.

For a N_1 exceedance greater than 10 seconds between 105% and 106.5% N_1, remove the turbine and compressor for inspection at Overhaul facility.

For a N_1 exceedance greater than 106.5% N_1, remove the turbine and compressor for inspection at Overhaul facility.

Figure 4: Rolls-Royce M250-C47B Manual extract

The engine

The helicopter's engine was disassembled and inspected by a Rolls-Royce approved engine overhaul facility in Brisbane, Australia. The tear-down report stated that the engine did not sustain any damage as a result of the reported Ng overspeed incident. Non-destructive testing of the compressor impeller and also the gas producer turbine wheels was conducted.

No defects were noted that were attributable to the overspeed (See attachment A). Severe and extensive corrosion of the compressor scroll, diffuser studs, and rear support were reported as being a 'cause for concern'.

The operator's engine historical records are currently spread across two separate log books. One was the original issued by Rolls-Royce, and the other was an Australian CASA issued log book. This led to some confusion over the engine's cycle history. The Rolls-Royce approved engine overhaul facility that conducted the post-incident inspection stated that the Time Since New was 2,280.75 hours and the Cycles Since New were 2,538.

Helicopter performance

The *HOGE* chart defines the helicopter's expected performance capability by selecting the proposed pressure altitude and temperature for the task. It assumes the helicopter is being operated within its limitations, with an engine producing 100% RPM. Where a helicopter is operated at a weight above its *HOGE* weight, a negative *HOGE* margin can initiate the main rotor *RPM* to droop (lose rotor revolutions per minute) with a subsequent loss of lift.

A helicopter operated at a weight below its *HOGE* weight, has a positive *HOGE* margin, where normal main rotor *RPM* would be expected. A helicopter operated at its *HOGE* weight has no *HOGE* margin. In this state, the helicopter becomes vulnerable to very small changes in the atmosphere and environment, such as wind, temperature and pilot control inputs. Those factors determine the power required and ability to maintain *HOGE* capability.

A positive *HOGE* performance margin ensures that when the proposed pressure altitude and temperature for the operation is determined, an established safety margin can be subtracted from that *HOGE* weight. For example, a 1% margin for the operation in this event would be 4,400*0.01= 44 lbs, therefore 4,356 lbs would be the target gross weight, a 5% margin would provide a 4,180 lb target gross weight. When applied and operating within *HOGE* weights with an engine providing expected power assurance, this target gross weight should permit the helicopter to hover, climb, take-off and transition into forward flight.

The Bell 407 *HOGE* weights assume zero wind conditions (*BHT-407-RFM page 4-4*). This indicates the *HOGE* weights identified at those pressure altitudes and temperatures are assured without any wind factored into the helicopter's performance.

The pilot's margin in this occurrence was 19 lbs, which was less than half of 1%. On final approach, to reduce the rate of closure and rate of descent to the helipad to position the load, additional power was required. If the pilot lost the 20 knots of head-wind as reported, near or directly over the helipad, the additional 20 knots of lift providing some performance margin, needed to be replaced to maintain the same closure and descent rates. In that case, the 0.004% margin available was insufficient to replace the margin provided by the head-wind. The pilot was unable to recall the performance margin from the helicopter operator's *Operations Manual* which governed the conduct of external load operations.

The pilot's recollection of the wind during the event albeit three 3 years later, did not reconcile with his report of a tail-wind in his statement two days after the event. In a tail-wind approach, the helicopter would require an even greater performance margin to overcome the rates of closure and descent, together with the aerodynamic power demands associated with down-wind flight. In that event, the margin available would be insufficient to overcome the closure and descent rates and down-wind aerodynamic effects for the approach.

In a nil-wind scenario on approach, the pilot would have 0.004% margin available to reduce rates of closure and descent for final approach and to hover the load over the helipad following the loss of translational lift effect on final. Even for a takeoff from Mt. Strong, the *HOGE* stipulated weight provides only 19 lbs of lift.

As the *HOGE* weight determined by the manufacturer used take-off power, this margin would not provide sufficient lift in nil wind to enable transition into forward flight. Therefore, in either a tail-wind or where the 20 knots of wind rapidly dissipated as reported by the pilot, the arrival margin was insufficient for the external load operation. Even the application of transient power was insufficient to safely manoeuvre the external load.

There was convective cloud in the area at Mt. Strong.

The duration of the first exceedance appeared to be more than 10 seconds. However, the elapsed time beyond 10 seconds was not reported. The next exceedance recorded the gas generator reaching a value of 106.2%, but the duration of the exceedance was not recorded.

The pilot reported that at high altitude, before Ng could be exceeded, the engine temperature would normally be exceeded first. This was not detected by the engine monitoring system. The pilot believed other pre-existing issues may have been responsible for the condition of the engine following its inspection.

With the cumulonimbus cloud activity reported, any effects of humidity at the time of the event, may have played a role in reducing helicopter performance. Although the *BHT-407 Flight Manual* makes no specific reference to humidity, the United States Federal Aviation Administration, advice in *Chapter 7 Helicopter Performance of the Helicopter Flying Handbook (FAA-H-8083-21A)* states:

> Maximum Gross Weight (page 6-2)
>
> 'Although a helicopter is certificated for a specified maximum gross weight, it is not safe to take off with this load under some conditions. Anything that adversely affects take off, climb, hovering, and landing performance may require off-loading of fuel, passengers, or baggage to some weight less than the published maximum. Factors that can affect performance include high altitude, high temperature, and high humidity conditions, which result in a high-density altitude. In-depth performance planning is critical when operating in these conditions.'

Factors Affecting Performance (page 7-2)

> 'Humidity alone is usually not considered an important factor in calculating density altitude and helicopter performance; however, it does contribute. There are no rules of thumb used to compute the effects of humidity on density altitude but some manufacturers include charts with 80 percent relative humidity columns as additional information. There appears to be an approximately 3–4 percent reduction in performance compared to dry air at the same altitude and temperature, so expect a decrease in hovering and take off performance in high humidity conditions. Although 3–4 percent seems insignificant, it can be the cause of a mishap when already operating at the limits of the helicopter.'

The high-humidity and high-density altitude environment of Papua New Guinea means pilots must carefully consider any effects that high humidity may have on helicopter operations and performance margins.

Engine examination post incident

The subsequent engine examination report indicated that the engine Anti-Ice Valve had failed in the open position. The Flight Manual only requires Anti-ice to be on in visible moisture conditions when ambient temperatures are at or below 5°C. Anti-ice would therefore not be required to be ON in the conditions reported by the pilot. If the Anti-ice valve defect occurred prior to the event at Mt. Strong, the Flight Manual HOGE chart with 'ANTI-ICE ON' indicates a performance reduction of 100 lbs should be expected.

The investigation was unable to determine when the Anti-ice system failed.

The operator

Heli Solutions is a helicopter charter operator, established in 2010, that provides B407 charter services across Papua New Guinea. Some of their main clients are the Government, Mining companies, telecommunications entities as well as groups and individuals. They have bases at Jacksons at the Jackson's International Airport in Port Moresby and also at Mt Hagen's Kagamuga Airport.

The operator had not complied with the requirement to have the 2,000-hour maintenance engineering inspection conducted. Following the removal of the engine after the serious incident, the operator requested that the engine overhaul facility conduct the 2,000-hour inspection along with the exceedance inspection. The overhaul facility found failed components during that work scope.

Engine exceedance occurrence 5 July 2017

On 15 March 2018, the AIC received a *CA005* notification from CASA PNG, together with documents obtained by CASA Airworthiness relating to a previously unreported engine overspeed occurrence involving a Bell 407 helicopter, registered P2-HSN, that occurred on 5 July 2017. The aircraft was being flown by the same pilot involved in the engine overspeed exceedance and release of external sling load serious incident at Mr. Strong on 2 May 2015.

The circumstances of the 5 July 2017 incident, as per the *CA005* and the pilot report, revealed that the engine overspeed exceedance audible alert sounded during the lift-off at Samberigi, Southern Highlands Province. The pilot induced an engine overspeed exceedance when he pulled collective before reaching 100% rotor RPM.

Experienced helicopter pilots and engineers have advised the AIC that the instrument check light will also illuminate at the time of an exceedance and will remain on until the engine is shutdown. For such an exceedance, the *Bell 407 Flight Manual* requires the helicopter to be shut down and a maintenance inspection to be carried out before further flight.

The pilot departed Samberigi with passengers and flew to Erave, a 2-minute flight. The engine was not shut down at Erave.

The pilot subsequently flew the helicopter to Mt. Hagen with a passenger and claimed that the *FADEC* light illuminated while enroute in the cruise. The veracity of the pilot's assertions is seriously doubted, given the Bell 407 *FADEC* system. The pilot had no way of knowing the extent of engine and transmission damage that may have been caused during the exceedance at Samberigi.

On arrival at Mt. Hagen on 5 July 2017, an analysis of the *FADEC* data by the operator's engineers revealed that the Ng peaked at 113.58% for 2.02 seconds. The engine was removed for overhaul.

The pilot and the operator did not report the incident on 5 July 2017 as required under *Section 60* of the *Civil Aviation Act 2000 (as amended)*, and *Part 12 of the Civil Aviation Rules*. At the request of CASA, the operator subsequently sought and obtained a brief statement from the pilot in March 2018. The pilot's statement and a letter from the operator dated 13 March 2018, together with a CA005 report, were sent to CASA on 13 March 2018. CASA subsequently informed the AIC.

This engine overspeed exceedance incident was not classified by the AIC as an ICAO defined Serious Incident. However, from the documented evidence/information provided to the AIC by CASA, there are issues of safety concern for the travelling public. The pilot's failure to comply with the *Flight Manual* requirements is also a serious operational safety concern. In accordance with *Section 244* of the *Civil Aviation Act 2000 (as amended),* the AIC advised CASA that an *Annex 13* investigation would not be conducted by the AIC and the incident was referred to CASA.

Note: The operator did not bring this occurrence to the notice of the AIC investigators during their investigation inquiries and document searches in Mt. Hagen between 6 and 8 March 2018.

The PNG Accident Investigation Commission (AIC)

The PNG Accident Investigation Commission is a statutory body of the Government of PNG, established under Part XIII of the *Civil Aviation Act 2000 (as amended) (CAAct)*. The AIC has a Board of three Commissioners, one of whom is the Chief Commissioner and Board Chairman. *Section 238* of the *CAAct* states that there shall be a Chief Executive Officer (CEO) appointed by the Head of State. The PIC was employed full-time as the CEO of the AIC.

Section 239 states that a person is not eligible to be appointed or continue in office as the CEO where he is engaged in an aviation business or corporate organisation which operates air services or provides air services in Papua New Guinea.

Section 240 (b) prohibits the CEO from engaging in paid 'employment' outside the duties of his office without the approval of the Commission (AIC Board). Such paid employment cannot include aviation employment.

However, contrary to *Section 239* of the *CAAct*, the former AIC Board approved the AIC CEO to engage in flying as a pilot in command for the purpose of re-currency.

The serious incident at Mt. Strong on 2 May 2015 occurred during the AIC CEO's paid employment as a pilot with Heli Solutions. The Ng exceedance occurrence on 7 July 2017 occurred during the AIC CEO's paid employment as a pilot with Heli Solutions.

The investigation highlighted irregularities in the application of the *CAAct* by the former AIC Board and the AIC CEO, specifically *Section 239 (1)* regarding engagement in aviation activities, and *Sections 247* and *248* regarding investigations.

Both occurrences were not reported to the Civil Aviation Safety Authority by the pilot (AIC CEO) or the operator (Heli Solutions) in accordance with *Civil Aviation Rule Part 12.55*. Furthermore, the serious incident on 2 May 2015 was not reported to the AIC by the pilot in any form.

The former AIC Board, on becoming aware of the 2 May 2015 serious incident, resolved to contract an aviation consultant to conduct an *"administrative investigation"* into the occurrence. The AIC Board did not cause an *ICAO Annex 13* investigation to be conducted. The investigation into the occurrence by an unqualified investigator contracted by the former AIC Board was not conducted in accordance with *Annex 13* or the *AIC Investigation Policies and Procedures*. Furthermore, the serious incident was not recorded or filed in the AIC records and the notification and reporting requirements were not met.

The consultant's *administrative investigation report* was never filed in the AIC report archives, nor was it filed with ICAO or published. When interviewed by the AIC investigators, the consultant provided a copy of his signed report which he stated was a copy of what he had provided to the AIC Board in 2015.

AIC Comments

Operational

It is likely the pilot detected the onset of power settling. With the convective cloud activity in the area, it is possible that this played a significant role in the development of the occurrence as a result of an unexpected wind shift, whether it was a tail-wind or complete loss of head-wind. It is possible the head-wind the pilot reported on approach, rapidly diminished in the convective atmosphere and that after the helicopter landed on Mt. Strong, the tail-wind observed by the pilot was the result of a wind shift.

In this event, with the negligible *HOGE* margin, convective wind behaviour and loss of translational lift on final approach to the helipad, it is likely the pilot detected the helicopter settling with power. This is a known condition while attempting to hover out of ground effect, such as during external loads, at pressure altitudes above the helicopter's hovering ceiling, when the wind is not aligned with the landing direction and with downwind and steep power approaches where airspeed is permitted to drop below 10 knots.

The pilot's initial actions to arrest the rate of descent by increasing collective pitch (causing the gas producer (Ng) exceedance) is consistent with the initial actions pilots tend to do to stop the descent. However, even the application of transient power above maximum continuous power, had no effect to arrest the rapid loss of lift, necessitating the pilot's immediate actions to jettison the load and avoid the full development of power settling.

The pilot had minimal positive *HOGE* margin on arrival at Mt. Strong. In the localised convective atmospheric conditions, it is possible the wind strength and direction, was erratic on short final to the helipad, severely altering the lift produced by the main rotor. The lack of any positive *HOGE* margin offered no power reserve for any unexpected changes. There is no evidence to suggest that the pilot considered using transient power prior to the flight.

However, the transient power utilised by the pilot during the occurrence, could not arrest the rate of descent with the external load attached, necessitating the jettison of the load. The presence of cumulonimbus cloud with active rain showers in the area, suggests downdrafts were possible. A different course of action, such as reducing payload and waiting for the cumulonimbus cloud to clear, would have increased the pilots *HOGE* margin.

While the pilot had fewer options at Mt. Strong, which likely hastened his decision to return to Bereina, on arrival at that location there was adequate time to consult the flight manual. This would ensure corrective action in accordance with the flight manual to determine the magnitude of the exceedance, permitting informed consultation with engineering support.

While the options the pilot faced at Mt. Strong may have presented a fast unfolding decision making situation, the decision to fly the aircraft without knowing the magnitude of the exceedance, only affected the safety of the aircraft and the pilot. The pilot's subsequent decision to fly from Bereina to Port Moresby with a passenger affected the safety of the loadmaster (passenger) in addition to the aircraft and pilot, and persons and property en-route.

The investigation notes:

1. The pilot's statement that he would not have been able to start the helicopter engine once it was shut down; was incorrect.
2. The engine can be restarted once shut down following a FADEC light illumination. However, in a caution note in the *BHT-407-Flight Manual*, the manufacturer specifies that *"applicable maintenance action must be performed before further flight."*
3. The pilot's assessment of helicopter out of ground effect performance did not provide an adequate positive margin for manoeuvring and unexpected conditions.

4. The pilot's assessment of the effects from nearby cumulonimbus cloud and subsequent convective activity, such as downdraughts with localised rainfall, did not consider the possibility of dynamic wind behaviour and its effect on helicopter performance.
5. High-humidity and high-density altitude adversely affect helicopter performance.
6. The pilot did not establish the magnitude of the exceedance in accordance with the aircraft flight manual before commencing the next flight sector.
7. The pilot did not comply with the *BHT-407-Flight Manual*, that specifies that *"applicable maintenance action must be performed before further flight."*

At Bereina the pilot did not consult the flight manual for the corrective action instructions, which would have allowed him to positively establish the magnitude of the exceedance. With the phone coverage available at Bereina, this would have meant the pilot could readily liaise with the operator's engineering staff in Port Moresby. The pilot hot-refuelled the aircraft and subsequently with a loadmaster on-board, flew on to Port Moresby.

The pilot's considerations of shutting the engine down and being stranded at Mt. Strong, the weather moving in around the mountain, and the accessibility for the maintenance required to such a remote site, likely influenced the pilot's decision on the course to return to the Bereina, refuel and return the aircraft to the maintenance facility in Port Moresby.

The Operator

The findings of the Rolls-Royce approved overhaul facility, were determined by the AIC to be as a result of poor maintenance and inadequate maintenance inspections, and the operator not complying with specified maintenance and maintenance inspection requirements. It is imperative, for safety, that all maintenance and maintenance inspection requirements be complied with and thoroughly completed.

The PNG Accident Investigation Commission (AIC)

The AIC Board does not have the authority to approve engagement by the CEO in aviation activities other than activities directly related to his employment as the AIC CEO. The former AIC Board gave the CEO approval to undertake recurrency flying. This was not in compliance with the CAAct.

The restriction on the CEO not to engage in employment with a aviation service provider or operator was not complied with by the CEO.

The investigation highlighted irregularities in the application of the *CAAct* by the AIC CEO, specifically *Section 239 (1)* regarding other employment, and *Sections 247* and *248* regarding investigations. The AIC CEO also did not comply with the *Public Service General Orders Section 20.4* with respect to outside employment.

The occurrence was not reported to the Civil Aviation Safety Authority by the pilot or the operator (Heli Solutions) in accordance with *Civil Aviation Rule Part 12.55*. Furthermore, the serious incident was not reported to the AIC by the pilot in any form. On learning of the serious incident, the former AIC Board did not cause an *ICAO Annex 13* investigation to be conducted. The report into the occurrence by an unqualified investigator contracted by the former AIC Board was not conducted in accordance with *Annex 13*, and the consultant's report provided to the former Board was never filed in the AIC Investigation Report archives, nor was it made public.

Conclusion

AIC Safety actions

While not causal to the serious incident, the following safety actions have been taken to ensure safety of aviation.

Bell Helicopters safety action

With reference to differences noted during the AIC investigation between the *Rolls-Royce M250-C47B Operation and Maintenance Manual* and the *BHT-407-Flight Manual* and *BHT-407-Maintenance Data-1 Manuals*, (page 4 this report), on 7 August 2018 Bell Helicopters informed the PNG AIC that:

(a) At the time of the event involving the subject helicopter 407 SIN 53726, the Ng speed limitations as published by RRC and Bell did indicate the same in our respective manuals.

(b) At some point after this incident, the Roll-Royce manual changed. ***Bell is in the process of updating the Bell manuals.*** *This update is not in any way related to this incident.*

Note: Emphasis added by the AIC for clarity of the safety action being taken by Bell Helicopters.

PNG AIC safety action

In order to ensure that the AIC is itself compliant with aviation legislation, in particular *Part XIII* of the *Civil Aviation Act 2000 (as amended) (CAAct)*, and to ensure that investigations are conducted without fear or favour, and there is no real or perceived conflict of interest or bias, the AIC has taken the following safety action.

All AIC employment contracts now state that the AIC is the sole employer of all AIC staff. The AIC Board has resolved that neither the CEO nor any staff of the AIC will be permitted to fly as a pilot for an aircraft operator within Papua New Guinea.

On 26 September 2017, the AIC Board promulgated a *Code of Ethics and Conduct* in the *AIC Policy and Procedures Manual* for all investigators, including the CEO and Commissioners. The *Code* complements the *Public Service General Orders Code of Conduct* and requires investigators at all levels up to and including the Commissioners to sign their acceptance and compliance. The aim of the *Code* is to bring a high level of integrity to ensure there is no room for non-compliance, and to ensure as far as is possible that all perceived or real conflicts of interest involving AIC staff and Commissioners are identified, and that breaches of the *CAAct* by AIC staff and Commissioners will not occur.

General details

Date and time	2 May 2015 00:20 UTC	
Occurrence category	Serious Incident	
Primary occurrence type	In-flight jettison of external load	
Location	Mt. Strong, Morobe Province	
Altitude	11,700 ft	
Coordinates	Latitude: 07°58’10”S,	Longitude: 146°56’40”E

Crew Details

Pilot in command	
Nationality	Papua New Guinea
Licence type	Commercial Pilot License (H)
Total hours	18,000
Total hours on type	2,000
Total hours last 30 days	11
Total hours last 7 days	11
Total hours last 24 hours	3

Aircraft details

Aircraft manufacturer and model	Bell Helicopters B407	
Registration	P2-HSL	
Serial number	53726	
Engine		
Manufacturer and model	Rolls-Royce	
Serial number	CAE847797	
Time since new	2,280.75 hours	
Cycles since new	2,538	
Type of operation	Sling Operation	
Persons on board	Crew: 1	Passengers: 0
Injuries	Crew: 0	Passengers: 0
Damage	No damage as a result of the exceedance. However, significant damage was noted by the engine overhaul facility assessed as due to lack of, and/or inadequate maintenance.	

Attachment A: APA teardown report, Revision 1

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TEARDOWN REPORT
Revision 1

Customer	HELI-SOLUTIONS
Order No	0188
Description	RR M250-C47B Engine Assembly
Part No	23063392
Complied By	Andrew Price

Work Order	013546
TSN / CSN	2280.75 / 2538
TSO / CSO	New / New
Serial No	CAE 847797
Date	30 July 2015

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1.0 Introduction

The engine was received at Asia Pacific Aerospace facility requesting to carry out :

1) N1 Overspeed Inspection - Gauge 106.2 % overspeed.
2) Engine 2000 Hour Inspection..

2.0 Receipt Condition

Engine was received with no signs of apparent shipping damage and all openings blanked as necessary.

The engine was noted as being very dirty, with extensive corrosion of the compressor scroll being immediately obvious.

3.0 Disassembly and Inspection Findings

The engine has not suffered any damage as a result of the reported N1 over speed incident. The required inspections for that event are non destructive testing of the compressor impeller and also the gas producer turbine wheels. No defects were noted associated with over speed.

Severe and extensive corrosion of the compressor scroll, diffuser studs, and rear support were cause for concern. It is not unusual for the exposed diffuser studs to break off when left in a corroded state. In this instance, several failed with almost no load applied at disassembly. Refer to images that indicate failure points.

The turbine module has achieved only 138 hrs TSO. Damage to 3 of the 4 bearings was noted as well as a significant failure of the 1st Stage Nozzle Assembly. (illustrated in following pages)

Following compressor and turbine disassembly, damage to components was noted.

- **Bleed Manifold**

Manifold which allows air to flow out of the inducer port, was corroded to a point where it is no Longer salvageable. A new Bleed Manifold will be required.

- **Compressor Shroud**

The component that is mounted directly over the impeller assy. Heavy damage to the abradable coating was observed. This is due to contact between the impeller and the shroud in operation. An exchange shroud is required. The impeller also sustained damage, but was able to be successfully blended. It is able to return to service.

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- **Diffuser Vane Assy**

As mentioned above, a number of the studs have failed. This will require replacement of the Vane assembly either by exchange or outright purchase of a new part.

- **Compressor Scroll**

The scroll assembly has been left in a badly corroded condition. Continued operation in this State would have led to compromising of the very thin walls of the scroll, with engine loss of power or total failure a very real possibility. The scroll is still considered salvageable, and a protective Sermetal coating will be applied for corrosion protection.

- **Turbine 1st Stage Nozzle**

The 1st stage nozzle was noted to have a large piece missing entirely from one vane. A close examination of the turbine did not show that any damage was caused by debris. A new nozzle of the most current production part has been recommended. That nozzle will also provide an noticeable increase in power over the previous configuration.

- **Turbine Bearings**

Of the 4 bearings supporting the gas producer and power turbine rotors, 3 were identified as not being acceptable for service due to scoring on # 6 and #7 rollers and rough running in the case of the #8. Bearings that fail that early after turbine installation often are linked to incorrect turbine installation pre-start procedures.

- **Combustion Liner**

The combustion Liner exhibiting cracking which we feel is repairable. The cost of these repairs can be extensive and easily reach the point of beyond economical repair. That part has been advance shipped to a Rolls Royce authorised repair station for assessment. A new part is held in stock should the repair cost be considered uneconomical.

- **Engine Records**

Engine historical records are currently spread across two separate log books. One the original Rolls Royce issue, and the second is a an Australian CASA issue log book. This led to some Confusion over engine cycle history.
Cycle history is not recorded, but the missing history was estimated at approximately 20 cycles, for which a correction can be made.

It was noted that the engine has not had its scheduled 2000hr inspection complied with. That Inspection has been incorporated into the existing work scope and complied with. Failures as a Result of that inspection were the Spur Adapter Gear Shaft, the compressor splined adapter, and the compressor to turbine coupling shaft. All due to excessive wear. In addition, a serious failure of the gearbox was averted. Refer to attached strip report for the gearbox module.

3.1 Engine Combustion & Miscellaneous Items

Parts removed were cleaned and inspected iaw applicable manufacturer manual.
Note that the Anti-Ice Valve was failed in the open position, likely contributing to a performance penalty.
Following are the major discrepant parts noted:

Nomenclature / Discrepancy / Disposition	Picture
Combustion Liner 23064570 CRACKS ON RELIEF SLOTS, DOUBLE LIP AREA & DEFLECTOR PLATE RELIEF SLOTS. [REPAIR]	 
Vertical Firewall 23032326	

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CRACK ON VARIOUS LOCATIONS. [REPAIR]	
ELEMENT, FUEL FILTER 23056451	2000HR inspection [REPLACE]

3.1.1 FUEL NOZZLE P/n 23077067 S/n AG60988 TSO : 280:75
To carry out cleaning and functional test.

3.1.2 HMU P/n 23078029 S/n JGALM1092 TSN : 2280.75
Unit cleaned and inspected found no discrepancy.
CEB 73-6054R1 carried out - Satis

3.1.3 ELECTRONIC CONTROL UNIT(ECU) P/n M250-10696 S/n JG8ALK0539
Unit cleaned and inspected found no discrepancy **TSN : 925.45**

3.1.4 BLEED VALVE P/n 23073353 S/n FF27650 TSO : 1239.85
Unit cleaned and inspected found no discrepancy

Note : All accessories inspected & No outstanding Alert CEBs / ADs due.

3.2 Compressor Assembly P/n 23065593 S/n CAC- 45615 TSN: 2280.75 CSN: 2538

Unit was disassembled to facilitate inspection/investigation to engine N1 overspeed. Parts removed were cleaned and inspected iaw applicable manufacturer manual.
2000 hours inspection c/o per Operation and Maintenance Manual.

Following are the major discrepant parts noted:

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Nomenclature / Discrepancy / Disposition	Picture
No.1 BEARING 23066716 Scoring on rollers [REPLACE]	
MATING RING 23004514 Scored sealing face. [REPLACE]	
SEAL ASSY 23004513 Fail leak test [REPLACE]	
BEARING, BALL 23009670 CEB 72-6067R1 COMPLIANCE. [REPLACE]	

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ADAPTER, SPLINED
23051117-1

UNACCEPTABLE STEP WEAR ON INT SPLINES.
Replace as per set.(SAGS MATING SPLINE F)

[REPLACE]

GEARSHAFT ASSY, SPUR ADAPTER
23073520

Failed 2000 hrs inspection - Stepped wear on fwd & aft splines.

[REPLACE]

REAR SUPPORT, COMP
23064593

CEB-72-6055R3 COMPLIANCE
TO C/OUT SERMETEL COATING.

[REWORK]

COMP SCROLL
23072862

TO REMOVE BROKEN FITTING. (SEIZED)
TO C/OUT SERMETEL COATING. (HEAVY CORROSION)

[REWORK]

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DIFFUSER VANE
23064637

BROKEN STUD (2EA)

[EXCHANGE]

MANIFOLD ASSEMBLY
23061239

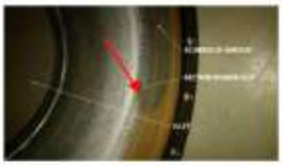
EXCESSIVE CORROSION @BOLT HOLE FLANGE AREA

[REPLACE]

COMP SHROUD
23061928

DEEP CIRCUMFERENTIAL SCORING & GOUGES ON CONTOUR SURFACE.

[EXCHANGE]



3.3 Gearbox Assembly P/n 23063393 S/n CAG-47797 TSN: 2280.75
2000 hours inspection c/o per OMM / CSL -6134R2 & CSL-6119 – Refer attached stand alone Strip report detailing findings.

3.4 Turbine Assembly P/n: 23063354 S/n: CAT 45153 TSN: 2132.8 TSO: 132.8

Mini-turbine was disassembled, cleaned and inspected for N1 overspeed inspection iaw the applicable manufacturer manual.

Following are the major discrepant parts noted:

Nomenclature / Discrepancy / Disposition	Picture
Coupling Shaft, N1 23032345 Stepped wear on SAGS aft splines - Replace as a set. [REPLACE]	
1st Stage Nozzle 23062061 Damaged vanes [REPLACE]	
BEARING, ROLLER, No.6 & 7 M250-10117 Scoring on rollers/Rough running [REPLACE]	
SLEEVE AND BEARING ASSEMBLY No.8 23058131 Rough running [REPLACE]	

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No.7 BEARING INNER RACE 6870031	Fretting wear [REPLACE]
SEAL METALLIC OMEGA-RING 23060164	Failed dimensional check [REPLACE]
VALVE SHUT OFF (Anti-ice) 23007827	Failed open (REPLACE)

4.0 Modifications to be embodied

AD/ENG/005 R9	Turbine Engine Continuing Airworthiness Requirements
AD/ENG/007	Replacement of life limited turbine engine components
CEB 73-6054R2	HMU One-Time Torque of Metering Head Regulator Cover Bolts
CEB 72-6067R1	Compressor –Replacement of no.2 bearing
CEB 72-6077R2	Spur Adapter Gearshaft Retaining Ring
CEB 72-6055R3	Compressor rear support assembly bearing lock key slot radii
CSL 6134R2	Gearbox, M250 Series IV Non-Intrusive Gear Inspection
CEB 72-6083	No.8 Bearing Manufactured By NHBB
CEB 72-6072	Release of new helical torquemeter gearshaft assemblies
CEB 72-6081	Replacement of oil delivery tube
CSL 6134R2	Gearbox, M250 Series IV Non-Intrusive Gear Inspection
CSL 6119	Oil Filter Cap

5.0 Summary

Following 2000Hrs Inspection, repair and modifications the engine shall be re-assembled and tested iaw the ***Rolls Royce M250-C47*** Series OHM as applicable for return to service.

Attachment B: Civil Aviation Act 2000 (as amended) extracts

Section 239. ELIGIBILITY FOR OFFICE.

(1) Subject to Subsection (2), a person is not eligible to be appointed or to continue in office as Chief Executive, where -

(a) directly or indirectly, as owner, shareholder, director, officer, operator, principal or otherwise, he -

(i) is engaged in an aviation business or corporate organisation which operates air services or provides air services in Papua New Guinea; or

(ii) has a financial or proprietary interest in any firm or corporate body referred to in Subparagraph (i); or…

(2) A Chief Executive -

(a) who, at the time of his appointment has an interest referred to in Subsection (1)(a); or

(b) in whom an interest referred to in Subsection (1)(a) vest by will or succession, shall dispose of it within three months from the date of his appointment or the date of vesting, as the case may be.

Section 240. VACATION OF OFFICE.

(2) Where the Chief Executive -

(b) engages, except with the approval of the Commission, in paid employment outside the duties of his office; or…

the Head of State, acting on advice, shall terminate his appointment.

Approved

Hubert Namani, LLB
Chief Commissioner
9 August 2018