FINAL REPORT ON ACCIDENT TO HELI- UNION COMPANY LTD. HELICOPTER SIKORSKY S76 C++ NEAR YETAGUN IN ANDAMAN SEA ON 11.07.2011

REPORT ON ACCIDENT TO

HELI- UNION COMPANY LTD.

HELICOPTER SIKORSKY S76 C++

NEAR YETAGUN IN ANDAMAN SEA ON 11.07.2011

1. Registered owner and operator	: Heli-Union Company Ltd.
2. Aircraft type	: Helicopter SIKORSKY S76 C++
3. Nationality	: French
4. Registration	: F-HJCS
5. Place of Accident	: Near Yetagun in Andaman Sea Latitude N 1446362 Longitude E 267324
6. Date & Time	: 11 July 2011 at 10 h 19 (local time)
7. Type of Operation	: Off-shore Operation
8. Phase of operation	: During take-off from FSO Helideck

SYNOPSIS

On 11 July 2011 the helicopter Sikorsky S76 C++ registered F-HJCS operated by Heli-Union took-off from Kanbauk Airfield with 7 passengers and 2 flight crews bound for the Yetagun Floating Storage Offloading (FSO).
After landing on the FSO, one passenger disembarked and three passengers boarded. During this phase, the rotor was still turning.
Then the crew intended to take-off to Yetagun platform. The captain (pilot flying) climbed vertically. At 25 feet above the platform, the pilot initiated a cyclic input, then the aural warning sounded and ENGINE OUT warning light illuminated on the instrument panel. The captain noticed the left engine T5 temperature increasing to the red zone (up to 983°C) and heard a clanking noise.
He decided to ditch the helicopter. He initiated the floating devices deployment. The contact with the sea surface was rather hard and the helicopter then capsized onto its left side. Flight crew and passengers managed to get out of the helicopter. All the crew and passengers were rescued after approximately one hour. Three occupants (including co-pilot) drowned to death and two other passengers suffered serious injuries. There were no signals detected from either the emergency locator transmitter or the personal locator beacons worn by the occupants of the helicopter.

1) FACTUAL INFORMATION

1.1) History of the flight

1.1.1) Pre-flight preparation

The morning of the occurrence, the crew completed their flight planning and prepared the helicopter. The first part of the flight consisted in landing on the FSO helideck which is about 110 NM from Kanbauk. The height of the helideck is estimated to be 50 feet.
The helicopter refuelled completely and hydro test. Seven passengers were on board. They received the required pre-flight safety briefing. The crew and passengers were provided with lifejackets for the offshore flight.
(For the flight, the captain occupied the right seat and was the pilot flying (PF). The co-pilot was seating on the left seat and was the pilot not flying (PNF).

1.1.2) Departure and En-route

The pilot took off from Kanbauk at about 09h00 local time. He flew along the route over the Andaman sea and made call at the designated reporting point wh 1, wh 2. He landed at 10h13 on the helideck of the FSO. A passenger disembarked and three passengers boarded. The FSO was oriented on a 215° heading, the wind was from 228° for 17-18 knots. The pilot hovered on heading 125° before take off. He then climbed vertically to 25 feet and took off to Yetagun platform located one nautical mile from the FSO.

1.1.3) Recognition of emergency and ditching

At 10h19, CVFDR and EVXP recorded that after take off passing 25 feet vertically, the aural warning sounded and ENGINE OUT warning light illuminated. The left engine temperature T5 was in the red zone (983°C read by the pilot) and the pilot felt the helicopter loosing power and heard a clanking noise. Because of the low height of the helicopter the pilot decided to ditch. He inflated all the four floating devices before touching the water surface.

1.1.4) Helicopter sinking and rescue

The contact with the sea was rather hard but the ditching took place without any problem. At that time the swell was approximately 2 meters and the wind resistance was approximately 90° right of the helicopter. Consequently after ditching, the helicopter capsized onto its left side. At that moment the roof windows were opened and water poured into the cockpit. The crew and passengers opened some jettison doors and got out within a few minutes by helping each other. All the life jackets and two life rafts were inflated and the PF managed to help his co-pilot and passengers.
The person on the FSO threw life buoys and positioned a ladder. Approximately 30 minutes later, the field standby boat assigned to Yetagun field, which was localised between FSO and the platform, arrived and continued the rescue operations.

After approximately 60 minutes, all crew and passengers were onboard. Co-pilot and two passengers drowned to death and other two passengers were seriously injured.

1.2) Injuries to persons

Injuries	Crew	Passengers	Others	Total
Fatal	1	2	-	3
Serious	-	2	-	2
Minor/none	1	5	-	6
Total	2	9	-	11

1.3) Damage to the aircraft

The helicopter was slightly damaged by the impact with the sea and it toppled just after ditching and the prolonged salt water immersion. The main rotor blades and tail rotor blades were broken. The right crew door, the window of the right sliding door, the right front window and the window of the left side door were missing, probably due to actions of the crew and passengers during evacuation.

1.4) Other Damage

There was no other damage.

1.5) Personnel information

1.5.1) Captain

Age:	45
Licence:	Airline Transport Pilot's Licence
Helicopter Ratings:	Sikorsky S76 C++, AS332, SA365
S76 rating validity:	valid to 31/12/2011

S76 base check:	valid to 30/11/2011
Line Check:	valid to 30/04/2012
Medical certificate:	valid to 30/09/2011
HUET	Valid to 28/02/2014
Flying experience	Total all types: 5158
	Total on type: 529
	Total multi-engine: 4641
	Last 30 days: 18
	Last 24 hours: 1
Offshore experience	1 173

The captain has been a helicopter pilot in the French army for 20 years. He has worked for civil operators specialized in offshore operations for 3 years. He is Flight Instructor (1555 flight hours in instruction) and Type Rating Instructor rated.

1.5.2) Co-pilot

Age:	57
Licence:	Airline Transport Pilot's Licence
Helicopter Ratings:	Sikorsky S76 C++, SA365
S76 rating validity:	valid to 30/04/2012
S76 base check:	valid to 31/10/2011
Line Check:	valid to 29/02/2012
Medical certificate:	valid to 08/12/2011
HUET	Valid to 24/02/2013
Flying experience	Total all types: 6338
	Total on type: 3165
	Total multi-engine: 3732
	Last 30 days: 28
	Last 24 hours: 1
Offshore experience	2 675

The co-pilot has been a helicopter pilot in the Myanmar Air Force for 21 years. He has worked for civil operators specialized in offshore operations for 10 years . He was a Flight Instructor (350 flight hours in instruction).

1.6) Aircraft information

1.6.1) General

Manufacturer:	Sikorsky Aircraft Corporation
Type:	S76C++
Aircraft serial number:	760740
Year of manufacture:	2008
Number and type of engines:	Turbomeca Arriel 2S2 engine n°1 S/N-42266
	Turbomeca Arriel 2S2 engine n°2 S/N-42265
Total airframe hours:	1186.27 hours
Total airframe landings:	1867 cycles

Certificate of Registration:	France registered on 10/07/2009
Certificate of Airworthiness:	issued by the European Aviation Safety Agency on 20.July 2009
Airworthiness Review Certificate:	expiring on 9 July 2012
Certificate of Release to Service:	issued on 11 July 2012 following a daily inspection

1.6.2) Aircraft description

The Sikorsky S76C++ is a twin-engine medium size helicopter, certificated by EASA Part 29 standards and capable of undertaking passengers or freight transport operations. It can be used in offshore oilfield support due to its long range. This helicopter has a four bladed main rotor.
The flight crew seats were equipped with five-strap retaining harnesses, with manual and automatic blocking system for the torso harness. The passenger seats were equipped with four-point seat belts with an automatic blocking system. Survival aspects are described in section 1.15 of this report.

1.6.3) Aircraft history

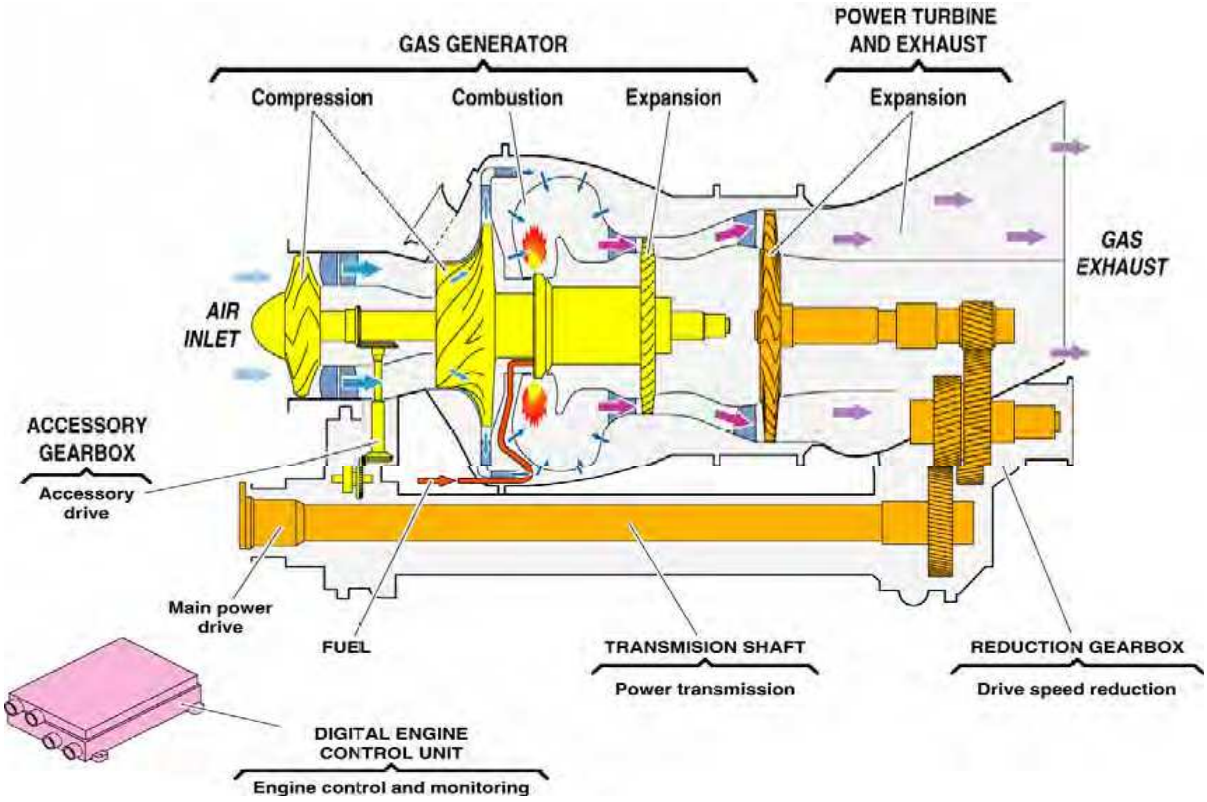
The helicopter was registered by French Civil Aviation (DGAC) on July 2009. The noise certificate and Certificate of Airworthiness were issued on 20 July 2009. The Air Operator Certificate (AOC) was delivered on 20 July 2009. The helicopter arrived in Yangon base on 12 August 2009. The last maintenance operation was carried out on 2 July 2011.

1.6.4) Recent activity

On 10 July 2011, the helicopter flew from Yangon to Kanbauk. The duration of the flight was 01h32.
On 11 July 2011, flight crew was performing the first flight of the day from Kanbauk to FSO which had duration of 55 minutes. During this flight, there were no anomalies.

1.6.5) Engines

The Arriel 2S2 engine is a turbo-shaft engine with a single-stage axial compressor, a single-stage centrifugal compressor, an annular combustion chamber, a single stage high-pressure turbine, a single stage power turbine, and a reduction gearbox with a nominal output at 6400 rpm. The engine is rated 923 shp (688 kW) at takeoff power and 833 shp (629 kW) at maximum continuous power.
The ignition system includes one high-energy generator, two injectors, and two igniters.



Last significant maintenance tasks:
5 July 2011 – Time Since New (TSN) = 1175 hrs: Torque stabilisation check in accordance with Maintenance Manual (iaw MM) task 71-02-00
25 June 2011 – TSN = 1164 hrs: Engine Power Check: Power margin = 4.5%, ΔT45 = 26℃
A 300 hours periodic maintenance check was performed on 19 January 2011 at TSN = 898 hrs.

1.6.6) Weight and balance

Due to the meteorological condition (monsoon), the helicopter refuelled completely at Kanbauk (1790 lbs) and the take off weight of the helicopter was 11 295 lbs. Before take off for Yetagun, the weight of the helicopter was 10 919 lbs.

	KBKAF	FSO
OEW	8279 lb	8 279 lb
Pax / payload ↘		1/235 lbs
Pax / payload ↗	7	3/526 lbs
Pax total	7	9
Payload tot	1236	1517
ZFW	9505	9796
TO Fuel	1790	1123
TOW	11295	10919
LDG Fuel	1183	
LW	10688	
CG (ok)	ok	ok
Endurance	2h50	1h47
Meteo		

1.6.7) Avionics

The S76C++ helicopter SN : 760740 F-HJCS is equipped with an offshore standard avionics system package with additional equipments which include an Automatic Flight Control System (AFCS) with a four-axis autopilot, 1 Traffic alert and Collision Avoidance System (TCAS), 1 Enhanced Ground Proximity Warning System (EGPWS), 4 Electronic Flight Information System (EFIS), 3 Integrated Instrument Display System (IIDS), Sky track system, 1 Multifunction Flight Display (MFD), 1 radio altimeter, GPS, Mode S Transponder, 1 EVXP Health and Usage Monitoring System and a weather radar. This aircraft is also equipped with the AFDS for flotation.

RADIO RECEPTION :
-**COM1**: Enables VHF 1 radio receive audio and volume control.
-**COM2**: Enables VHF 2 radio receive audio and volume control.
-**COM3**: NPX 138N - High Band VHF-FM
-**COM4**: HF radio receives audio and volume control.
-**COM5**: Sky Track ISAT 100

1.6.8) Caution and Warning Panel
1.6.8.1) Master warning panel

Captain and co-pilot have a master warning panel on their own instrument display. The master warning panel consists of an amber Master Caution light, four red lights (ENG1 FIRE, ENG 1 OUT, ENG 2 FIRE, ENG 2 OUT) and spaced outboard, two blue “ENG CONTROL PRESS TO DIM” lights. To direct the pilot’s attention to the IIDS displays when a warning or caution light goes on, the MASTERCAUTION PRESS TO RESET light will also goes on. After the condition has been noted, the master caution should be reset to allow it to light again if another caution light should go on. The master caution light does not lit when an advisory light on the performance display goes on.

1.6.8.2) Engine failure warning system

When the n°1 or n°2 ENG OUT red warning light goes on a tone (550 Hz and 700 Hz) will be heard in the headset in two cases:

- When the DECU engine failure detection logic detects an engine out condition for that engine or
- When N1 for the corresponding engine drops to 48%.

The alternating tone signal is inoperative when the helicopter is on the ground; however, the warning lights will be on whenever N1 is less than 48%.

1.6.9) Emergency Locator Transmitters

The helicopter is equipped with two Emergency Locator Transmitter (ELT) 406 AF. A fixed one(ADT406)is installed in the tail boom and has a G-switch.The second one (500-12Y) is portable and installed between the two pilots seats.The ELT can be detected by S&R Satellite constellation and located with a precision of 2 km. The contact with the sea was too smooth to activate the fixed ELT. Neither the PF nor the PNF have activated the portable ELT. No signal was recorded during the event.

1.7) Meteorological information

1.7.1) Synoptic situation

Due to the full monsoon seasons, weather of Kanbauk was raining lightly.

1.7.2) Available forecasts

Wind direction was south westerly, speed 16 to 21 knots with gust, swell direction south coast, swell height 2 meters.

1.7.3) Platform weather

Yetagun Field weather observation: on 11 July at 10h38, surface wind was 228° 17 to 18 knots, temperature 28.2℃, QNH 1006.2 Mb, sea was moderate, swell was westerly 2 m, ceiling was overcast.

1.8) Aids to navigation

1.8.1) Platform navigation aids

FSO is equipped with Non Directional Beacon. The frequency is 529 MHz.

1.8.2) airborne navigation aids

The S76C++ is equipped with a Collins ADF 462. This system permanently informs the crew of the bearing of a ground transmitter. The information is displayed on the EHSI, which enables its reading directly in the form of a QDM.

1.9) Communications

The S76C++ makes first contact with the FSO on FM chanel 6 then the second contact on frequency 118.7 MHz.

1.10) Airfield information

The helideck is located on the Yetagun FSO which is a tanker. The location is N13°3.85'and E096°51.22'. The height is 50 feet wit h maximum mass of 9 tons. The FSO is 1 NM away from Yetagun Platform. In case of engine failure and flight on single engine, the alternate airfield is Dawei located at 100 NM away.

1.11) Flight recorders

1.11.1) SSMVDR

The helicopter was equipped with one Solid State Memory Voice/Data Recorder.
Manufacturer Honeywell
Model 6021
Part Number 980-6021-066
Serial Number ARCOMBI-12023

The SSMVDR is the mandatory flight recorder on board. This records 110 hours of data and 2 hours of audio. The audio recordings include the Captain's and co-pilot's communications, radio transmission, passenger announcements and audio from the cockpit area microphones (CAM). The SSMVDR and its

recordings were successfully recovered. The data and audio recording stopped a few seconds before the impact.

The recorder was equipped with an Underwater Locator Beacons (ULB) attached. These devices are set on contact with water and must transmit a signal for at least thirty days.

Read-out operations of the SSMVDR were performed on 12 December 2011 in the BEA. All the data was recovered from the flight data file by reading out the memory chips. The flight of the event is recorded. Preliminary data were plotted and listed.

The file containing the voice data was then decompressed with Playback tool software utility (998-3414-507) into the standard audio wave files.
The four audio files could be identified as follow:

- three files containing the last two hours of recording of captain (track 1), co- pilot (track 2), every one mixed with VHF communications, and a third channel usually called ‘flight engineer-or public address’ (no data on this channel for this helicopter - seems to be not connected as per design),
- One file containing the last two hours of recordings of the Cockpit Area Microphone (CAM).

Transcription is in appendix A (CVR transcription)
Technical report of the SSMVDR examination is in appendix B (Tech: doc SSMVDR)

1.11.2) HUMS

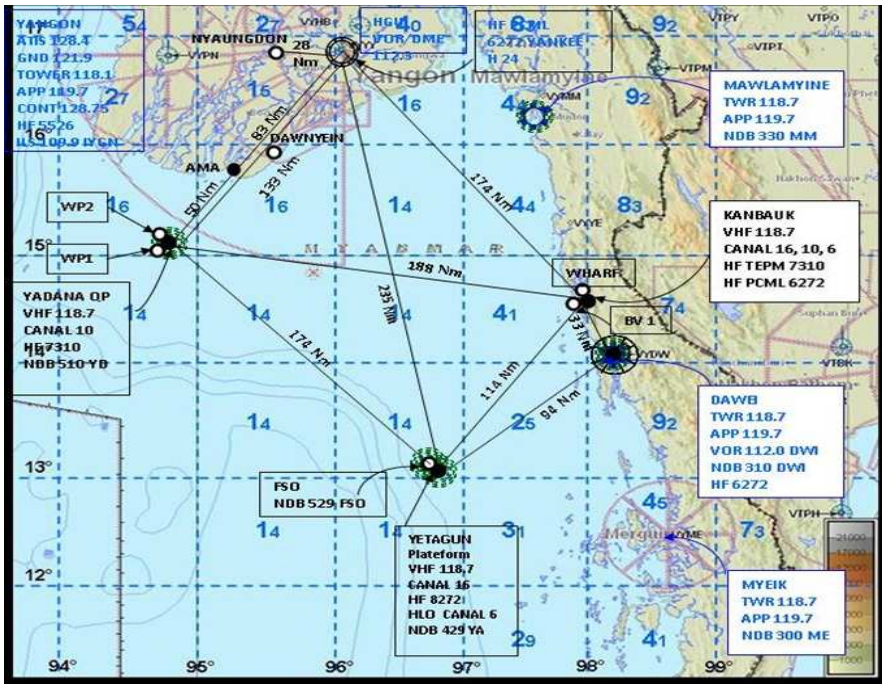
The helicopter was equipped with a Health and Usage Monitoring System (HUMS Honeywell eVXP). This equipment records additional parameters which are not recorded by SSMVDR.
The data provided by the eVXP are consistent with the ones provided by the SSMVDR.
It shows that engine #1 torque reached 150% as engine #2 torque went to 0%.
The pilot initiated a cyclic input and simultaneously the engine #2 failure occurred. The helicopter was at a height of 25 feet above the helideck.
Technical report of the EVXP examination is in appendix C (Tech: doc eVXP exam)

1.12) Wreckage, site and impact information

1.12.1) The site

The coordinates of accident site are latitude N13°04.05’ and longitude E096°51.52’
The depth is around 100 meters.
The helicopter ditched near the FSO, at approximately 50 meters. Then it drifted about 700 meters. The wreckage was located at 940 meters in the 328° direction from the last known position. No particular debris were found and the seafloor is flat.

The helicopter was put in a cargo net and was lifted out of water.



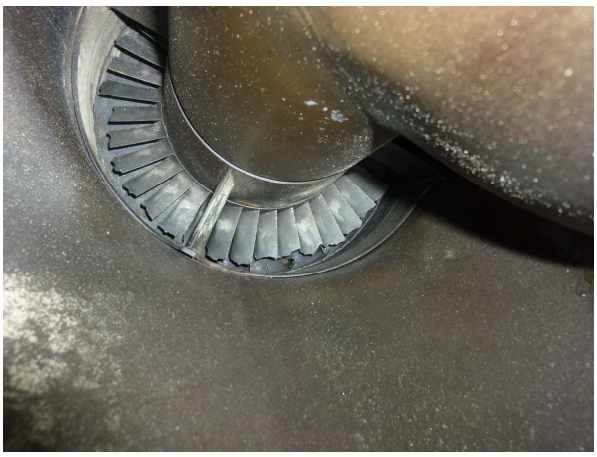
1.12.2) Initial visual examination

The airframe was in good general condition. The tail boom was damaged and partially separated from the cabin probably due to the contact with the sea surface and then with the seabed and increased by the recovery operations. The main gear box was severely damaged due to its housing corrosion. The main rotor head came off during the recovery operation.
All four main rotor blades were broken off from the rotor head and the remaining sections still attached were approximately 50 cm in length. The blades were not recovered.
The tail rotor blades were broken off from the tail rotor assembly and not recovered.The cabin and cockpit including instrument panel and controls were in good condition.

1.12.3) Engines visual examination

The general aspects of the engines appeared in good condition and were locally covered with deposits which were a consequence of the time spent in sea water. Engine #
1 (s/n 42266) did not exhibit any pre-accident damage with no particular findings to report.

The on-site boroscopic examination of engine #2 (s/n 42265) revealed damages to the blade tips of both high pressure turbine (gas generator) and power turbine (free turbine). The pipes at the accessories gearbox breather gear output and at the bleed valve output were found disengaged. The moment of their disengagement could not be established. The disengagement of those pipes does not affect the engine's ability to deliver the required power. There were no other significant findings on engine #2.



1.13) Medical and pathological information

The co-pilot and two passengers passed away of cardiopulmonary arrest due to drowning. Two persons were seriously injured, suffering back and chest pain.

1.14) Fire

There was no fire.

1.15) Survival aspects

1.15.1) Flotation system – inflation

The helicopter was equipped with an emergency flotation system consisting of four inflatable units. A flotation bag was installed on each main landing gear compartment door and two were installed in compartments next to the nose landing gear. The emergency flotation system was successfully inflated by the PF just before ditching. The picture below shows that the devices were inflated.

1.15.2) Survival life rafts

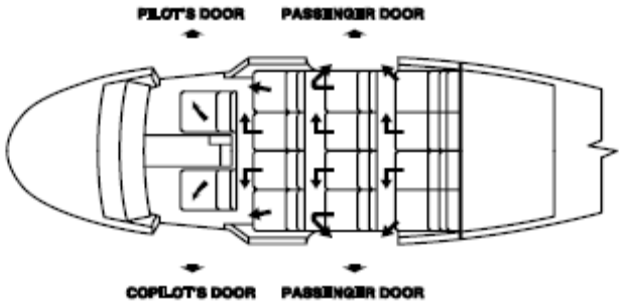
The helicopter was equipped with two identical life rafts model RFD Aerolite 10 with a rated capacity of 11 occupants and overload capacity of 17 occupants mounted on the exterior of the aircraft below the right and left hand cabin doors. The two life rafts were inflated.

1.15.3) Life Jacket

The flight crew and each passenger were equipped with life jacket MK28. All passengers had their jacket inflated.

1.15.4) Helicopter evacuation

All emergency exits must be usable at all times, except if an official concession is obtained. All emergency exits of F-HJCS were usable. The captain evacuated through the right pilot's door while the passengers and the co-pilot evacuated through the window of the right sliding passenger door.



14 PLACE CONFIGURATION

1.15.5) Survival training

1.15.5.1) Crew training

The captain and the co-pilot had trained a Helicopter Underscape Escape Training. It consists in evacuating a generic submerged cabin with safety belt fastened, lifejacket on, inflating the lifejacket in the water and getting onto an inflated lifeboat.

1.15.5.2) Passengers training

All passengers had trained a Helicopter Underscape Escape Training as well.

1.15.6) Search and Rescue organisation

The International Association of Oil and Gas Producers (OGP) have issued Aircraft management guidelines in order to provide a ready reference for the management of aviation.
These guidelines and the readily available support from Aviation Advisers should assist those responsible for managing aviation, particularly if they are not aviation specialists, to plan, develop and control, safely and efficiently, air transport operations that are best suited to their needs.
The part 12 describes the emergency response planning. "*Each OGP Member's site operation or asset using aviation services should make provisions for aviation emergencies in their Emergency Response Plans (ERP) and communicate these plans to all relevant personnel.*"
For both FSO and Yetagun platform, an ERP was available.

1.15.6.1) Floating Storage Offloading (FSO)

The FSO arrangements Manual, Chapter 2 Emergency Response, section 5 Helicopter emergencies, part 1.2.2, describes the procedure in case of Helicopter Ditching in the vicinity of the FSO. "*Preferably, the field stand-by boat will be in close support around the FSO with the fast zodiac ready for immediate launch. If the stand-by boat cannot be in close support, i.e. because there is an offload taking place, and she is secured to the export tanker or she is deployed elsewhere in the field, then the fast zodiac should still be available for launch. If the above is not possible, then the FSO starboard lifeboat should be ready for immediate launch. Should the helicopter ditch, the ability to reach the crash site*

as quickly as possible is essential… Once personnel are recovered from the helicopter, they should be taken to a safe refuge as soon as possible, which may be the stand-by boat, the FSO or the Yetagun platform".
Cf appendix D (Yetagun, FSO arrangement Manual, chap-2,sect-5,1-2-2)
When the accident occurred, the field stand-by boat was closed to the Yetagun Platform. The FSO personnel launched only life buoys and positioned a ladder. The FSO starboard lifeboat was not used. FSO personnel waited for the field standby boat to come from platform.

1.15.6.2) Yetagun platform

The PCML Emergency Management Plan describes in introduction that "*This Emergency Management Plan has been developed in order to provide guidelines to the on-duty emergency management team who are directly or indirectly involved, when responding to emergencies occurring at PCML operational areas. The document has been developed to complement the existing Site Emergency Response Plan, which covers in detail the required response to specific emergencies.* Cf appendix E (PCML Emergency Management plan, part-1.2)
The PCML has established specifically for Yetagun's site the "Yetagun A & B Emergency Response Plan" by PC Myanmar. The preface explains that *"This Emergency Response Plan has been developed to ensure that PCML reacts quickly and effectively in the event on an emergency in the Yetagun field".*
The objective of the Manual part 1.2 describes: "*The document describes the actions that are taken to mitigate, control, or evacuate from emergency situations and identifies responsibilities, procedures and equipment available to provide an effective response".* Cf appendix F (Yetagun A&B emergency response plan, part-1.2)

In case of helicopter ditching – part 5.4.3 Helicopter Ditching - the On Scene Commander (this role is normally filled by the platform Offshore Installation Manager who is in charge of the emergency response on the Yetagun field – part 2.1.1) will:

- Instruct Radio Operator to direct the stand-by vessel to the location of the ditched helicopter.
- coordinate all actions necessary to assist the ditched helicopter in conjunction with the FSO and Onshore ERT.

During the rescue operations, the OSC had several phone contacts and managed the field standby boat in order to pick up the crew and passengers.

1.15.6.3) Research and recovery of the helicopter
1.15.6.3.1) First Search campaign

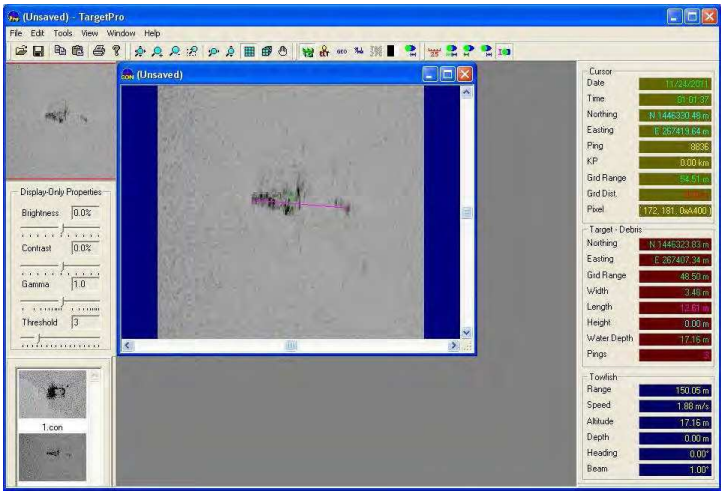
After the accident, Heli Union appointed Singapore Salvage Engineers Ltd to carry out the hydrographical survey for the search of the sunken helicopter in the Yetagun field. The objective was to locate the wreckage using Multi beam

Echo Sounder (MBES), Side Scan Sonar (SSS) and Magnetometer within the determined area. The operation took place from 22 to 27 August 2011.
No pinger signal from the CVFDR ULB was detected by the MBES during the survey.
The wreckage location could not be confirmed in MBES and SSS survey records causing delays in the survey operation.
Due to bad meteorological conditions, strong sea current and time constraint the whole pre-planned survey had to be terminated.

1.15.6.3.2) Second Search campaign

A second campaign was organised from 23 to 27 November 2011. Heli Union contracted Seascape Survey Pte Ltd to carry out the survey and recovery with a dedicated vessel. 2 ROVs, 1 GeoAcoustic Dual Frequency Side Scan Sonar and a R2 Sonic 1024 Multi beam Echo Sounder were operated on board. The hired vessel was equipped with a crane adapted for recovery operation. A technical advisor from Comex was on board to assist and advise the operations.

On 24 November, the Side Scan Sonar and Multi beam Echo Sounder survey defined two targets which were interesting and corresponding to the same position. As the multi beam was not sufficient to detect the wreck, a ROV was launched.



20 minutes later the helicopter wreckage was discovered. On 26 November, the rotorcraft was lifted out of water and loaded on board the vessel.

As soon as the helicopter had been secured, the SSMVDR, DECUs and eVXP were removed and preserved. The engines had been cleaned and protected in accordance with Turbomeca procedures. Then the vessel started the transit to Yangon Harbour and arrived on 27 November.

1.16) Test and research

1.16.1) Engines examination

1.16.1.1) Visual examination

Arriel 2S2 engines examination has been performed in Turbomeca plant from 14 to 16 December 2011. cf appendix G (Arriel 2S2 engine Turbomeca Examination)

Engine #1

The accessories gearbox, axial compressor, gas generator, power turbine and reduction gearbox were in good condition and were locally covered with deposits which were a consequence of the time spent in sea water.
The HP turbine wheel assembly was analysed. All the blades and the disk were checked with dye penetrant inspection that did not reveal any cracks.

Engine #2

The accessories gearbox, axial compressor and reduction gearbox were in good condition and were locally covered with deposits which were a consequence of the time spent in sea water.
The gas generator
The centrifugal compressor: the centrifugal wheel exhibited light rubbing traces across the blades' top edges. The compressor front cover exhibited several local rubbing marks at inlet and outlet levels.
The combustion chamber was in good condition.

The high-pressure blade: the HP turbine wheel had one blade broken below its platform near the top of the fir tree root. All the other blades were normally positioned on the disk and exhibited impact damage and material loss above their platforms.
The HP turbine shroud and the trailing edges of the nozzle guide vane's (NGV) vanes exhibited impact marks indicative of multiple collisions with the blades' debris.
The power turbine
The nozzle guide vane's (NGV) vanes trailing edges exhibited impact marks.
The power turbine blades, normally positioned on the disk, exhibited impact damage and material loss above their platforms. This resulted from HP turbine blades' debris being sent down the air path and colliding with the power turbine blades.

1.16.1.2) HP turbine components analysis

The engine #2 HP turbine wheel assembly was analysed. The examination identified the fatigue rupture of blade #6 below the platform. Damages to the other blades above the platform were consecutive to the rupture of this blade.

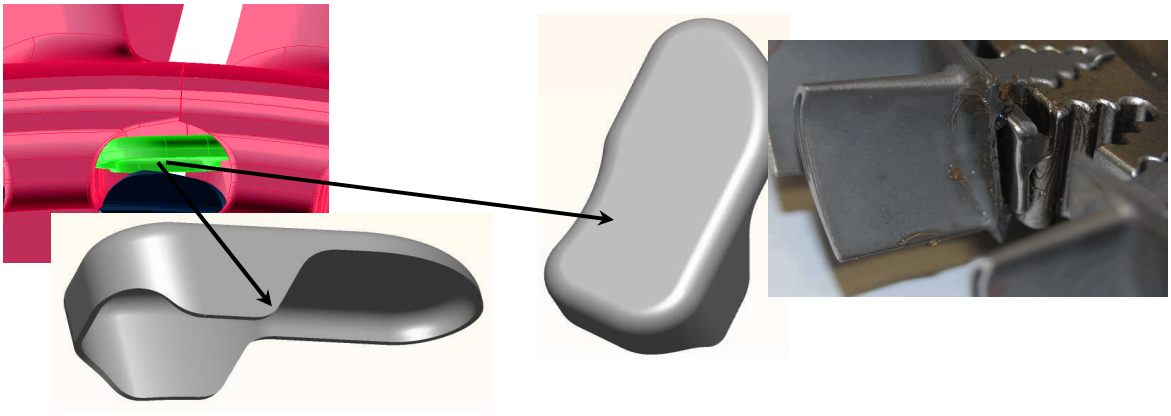
1.16.2) Previous cases

Turbomeca has identified blades failure phenomenon on the Arriel HP turbine since 2007.
On Arriel 2S2 engines, 7 cases of HP broken blades and 18 cases of cracked HP blades have been listed between February 2007 and December 2011.
For the year 2011, 4 cases of in-flight engine shutdowns have been registered on Arriel 2 engines (2 events on Arriel 2S2 engines including the F-HJCS accident).

The probable scenario of the blades' failure is a rupture excitation of one of the vibration modes of the HP blade in conjunction with several secondary contributing factors deemed sufficient to reduce the stress margin of the HP blade to a level consistent with the occurrences of ruptures encountered.
Turbomeca has performed corrective actions through the TU166 modification:

- Alert service letter n°2539/07/ARRIEL2/25 version 8 issued on 9 February 2012 (first version issued in April 2007) cf appendix L,
- service letter n°2784/10/AR2S version 1 of 19 Nove mber 2010 and
- service bulletin n°292 72 2166 version F of 13 May 2011 (version A issued in March 2009).

The EASA has issued Airworthiness Directives AD 2010-0198 and AD 2012-0124 mandating the accomplishment of TU166 modification.
The service letters and the service bulletins describe how to apply the TU166 modification and the applicability criteria.
The F-HJCS had not been retrofitted with TU166.
It consists of adding a damper in the inter-blade area under the platform and reinforcing inspections on new and repaired HP turbine wheels.



1.16.3) Performance during take off

In his check list, the pilot has two charts in order to determine if the take off will be in performance class 1 or 2.
Regarding meteorological conditions (28℃), height of the helideck (50 feet) and weight of the helicopter (10919 Lbs) for the flight of the event, the pilot had to proceed performance class 2 take off.

MTOW - PC 1 – Elevated helipad (Unfactored wind)							
OAT / Helideck Height	25° c Vw 0 to 10 kt	30° c Vw 0 to 10 kt	35° c Vw 0 to 10 kt	25° c Vw 20	30° c Vw 20	35° c Vw20	40° c Vw 20
75 ft	10300	10150	9850	11150	10900	10500	10150
95 ft	10650	10450	10250	11650	11300	11000	10600
115 ft	11450	11100	10850	11650	11650	11650	11450
135 ft	11450	11150	10850	11650	11650	11650	11450

with exposure time

MTOW - PC 2 - DPATO = 74 Kt/200ft CLEAR HELIPORT - HELIDECK							
OAT / HP	15° c	20° c	25° c	30° c	35° c	40° c	45° c
0 ft	11700	11700	11700	11700	11600	11250	10920
200 ft	11700	11700	11700	11700	11550	11200	10820
500 ft	11700	11700	11700	11550	11350	11050	10680
Performance guarantied 1000 ft above heliport/helideck							

1.17) Organizational and management information

1.17.1) The operator Heli-Union

Heli Union was founded in 1961. It has an Aircraft Operator Certificate number F-N049 valid till 20 june 2014. Following the French directives (OPS 3), it has deposited an operations manual approved by DGAC. The last authorities audit was performed in Feb 2010 for operations in Myanmar.

Organization

Heli Union operates helicopters on 10 sites under its own AOC:

- Issy les Moulineaux Heliport (headquarter, France)
- Toussus le Noble Airfield (Main maintenance center, France)
- Angoulème Airport (Training center, France)
- Tripoli (Lybie)
- Port Harcourt (Nigeria)
- Port Gentil (Gabon)
- Pointe Noire (Congo)
- Douala (Cameroun)
- Kanbauk (Myanmar)

The fleet is composed of 8 Sikorsky helicopters S76C++, 14 Eurocopter AS365 (N+N3) helicopters, 2 Eurocopter AS332L1.
90 pilots are authorized to perform public transport operations.

The company is organized as follow:

- Accountable Manager
- Operations Manager-(accountable post holder for Ground and Air operations)
- Training Manager
- Maintenance and Airworthiness Manager
- Quality and Safety Director
- Flight Safety Officer (FSO)

Operations

The company operations manual includes operational information, regulation information and instructions in order to carry out flight operations and ensure supervision of the services with trained personnel and adequate means.

Myanmar base

Heli-Union has an operating base in Maynmar (Yangon + Kanbauk) since 2008 with 2 S76C++ under its AOC registered. Five pilots, five engineers (A&C and avionics) and fifteen support staff are based in Myanmar. The organisation on site is built with a base manager (who is also the flight safety officer and chief of operations) and a technical manager.

1.17.2) Performance class 2

In 2000 the Joint Aviation Authorities Committee, representative of several European Civil Aviation Authorities, issued a document called Joint Aviation Requirements for Commercial Air Transportation (Helicopters) JAR-OPS3.
France implemented these requirements in a specific Decree, OPS3, that entered into force on 1 June 2000.

The Subpart F –general performance
Defines category A as multi -engine helicopters designed with engine and system isolation features specified in JAR-27/29 acceptable to the Authority and Helicopter Flight Manual performance information based on a critical engine failure concept which assures adequate designated surface area and adequate performance capability for continued safe flight in the event of an engine failure.

The subpart H –class 2 performance
Definition: Performance Class 2 operations are those operations such that, in the event of critical power unit failure, performance is available to enable the helicopter to safely continue the flight, except when the failure occurs early during the take-off manoeuvre or late in the landing manoeuvre in which cases a forced landing may be required.
An operator shall ensure that helicopters operated in Performance Class 2 are certificated in Category A. OPS 3.515. Cf appendix H (JAR-OPS 3, Section 1, subpart H, JAR-OPS 3.515 General, page 1-H-1)
The operators wishing to operate their helicopters in performance class 2 without an assured safe forced landing capability during the take off and landing phases (with exposure time) must obtain an approval from the competent authority in accordance with appendix 1 to OPS 3.517 (a). Cf appendix H (JAR-OPS 3, Section 1, subpart H, JAR-OPS 3.517 Operations without an assured safe forced landing capability, page 1-H-1)

The appendix 1 to OPS 3.517 - The Advisory Circulars Joint/ACJ-1 to appendix 1 OPS3.517
In order to obtain an approval for operations with exposure time the operator must provide a risk assessment analysis to the authorities. Cf appendix H (JAR-OPS 3, Section 1, subpart H, Appendix 1 to JAR-OPS 3.517 (a) Helicopter operations, page 1-H-3)
The ACJ introduces a power plant system reliability assessment to demonstrate the eligibility of the helicopter for operations with an exposure time to a power unit failure during take-off or landing. The eligibility requires establishing that the probability of power unit failure during the exposure time is not higher than 1 per 100,000 engine functioning hours over a five years sliding period. A higher rate not exceeding 3 per 100,000 hours of functions could be accepted by the authority after an evaluation showing an improvement.

1.17.3) Heli -Union operations

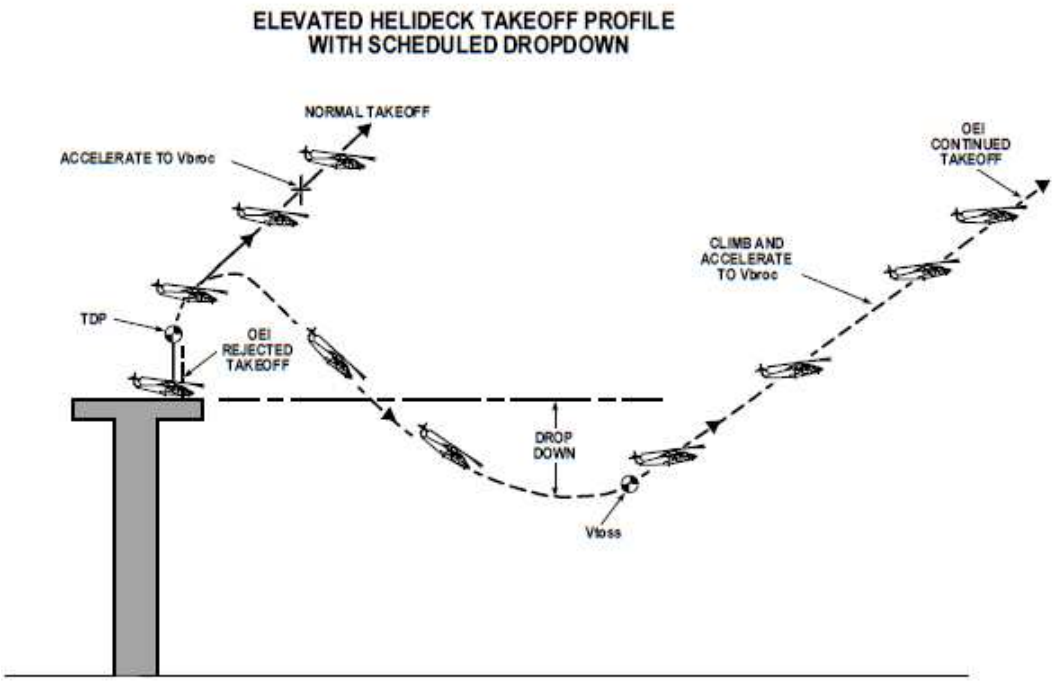
From helideck, the Sikorsky S76C++ helicopters are operated in category A and class 2 performance. Heli-Union is authorized to conduct operations without an assured safe forced landing capability during the take off and landing phases.
This approval was given by DGAC after registration of the helicopter Sikorsky S76C++ on the eligibility list on June 2009.
DGAC received data and information from the manufacturer for the period 2003-2007 between February and June 2009. The updated in-flight sudden power loss rate for engine and helicopter for each Sikorsky engine/helicopter model (S76A, S76B, S76A+/S76A++/S76C, S76C+/S76C++) was less than 1.00 per 100 000 flight hours. Cf appendix H (JAR-OPS 3, Section 2, Subpart H, ACJ-1 to Appendix to JAR-OPS 3.517 (a), page 2-H-13) and appendix I (BEA recommendation)

The DGAC, after several requests to the manufacturer, obtained at the end of 2011 the updated data for the period 2005-2009.
Following the engine examination of the F-HJCS, the BEA asked to the manufacturers (helicopter/engines) the actual data for the period 2007-2011. The figures showed an engine failure rate of 0.85 per 100,000 flight hours concerning the Sikorsky S76C++. This rate is lower than the maximum value of 1 per 100,000 and only takes into account failures that are caused by the engines. cf appendix I (BEA recommendation)
However, for the year 2011, 4 events of engine shutdowns in flight have been registered, one of which was the accident.
In January 2012, the statistics for the period 2006-2010 were neither available nor provided to the authorities.

1.17.4) Take off procedure from helidecks

1.17.4.1) Engine failure during take off - Flight manual

The procedure for an engine failure during take off on elevated helideck describes that: "*the procedure to follow after an engine failure during a vertical take off depends on where in the take off sequence the failure occurs. If the engine fails before the TDP, the take off is rejected and the aircraft is landed on the helideck. The TDP is 30 ft above the take off surface. If the failure occurs after the TDP, the take off will be continued*." Cf appendix J (S76C++ Flight Manual, Part 2. section IV, supplemental, performance Data page 4-59)

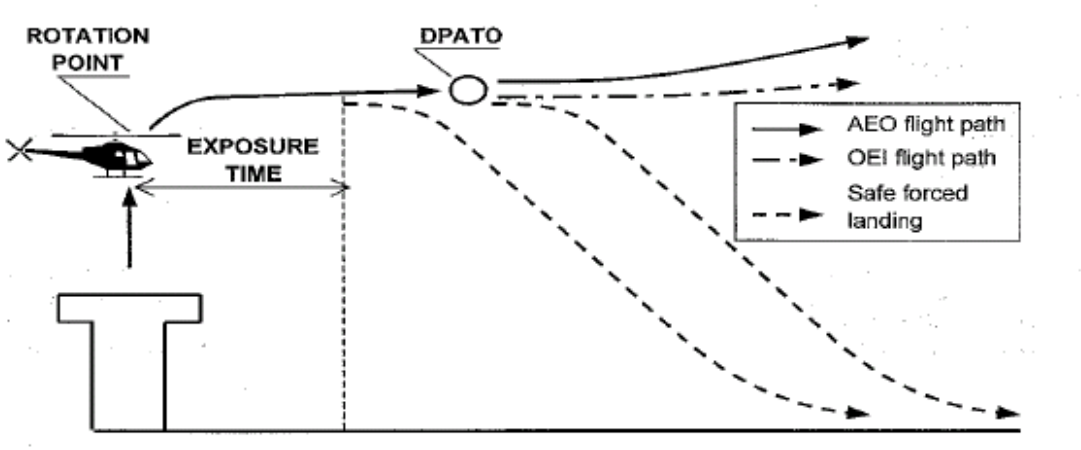


1.17.4.2) Operations regulation in performance class 2

The Interpretation Explanatory Materiel/IEM OPS 3.520 prescribes that: "*in two cases of take off and landing, exposure time is used. During the exposure time (which is only approved for use when complying with Jar OPS 3.517(a), the probability of a power unit failure is regarded as extremely remote. If a power unit failure (engine failure) occurs during the exposure time a safe force landing may not be possible*". Cf appendix H (JAR, OPS-3, sect-2, subpart H, page 2-H-19)

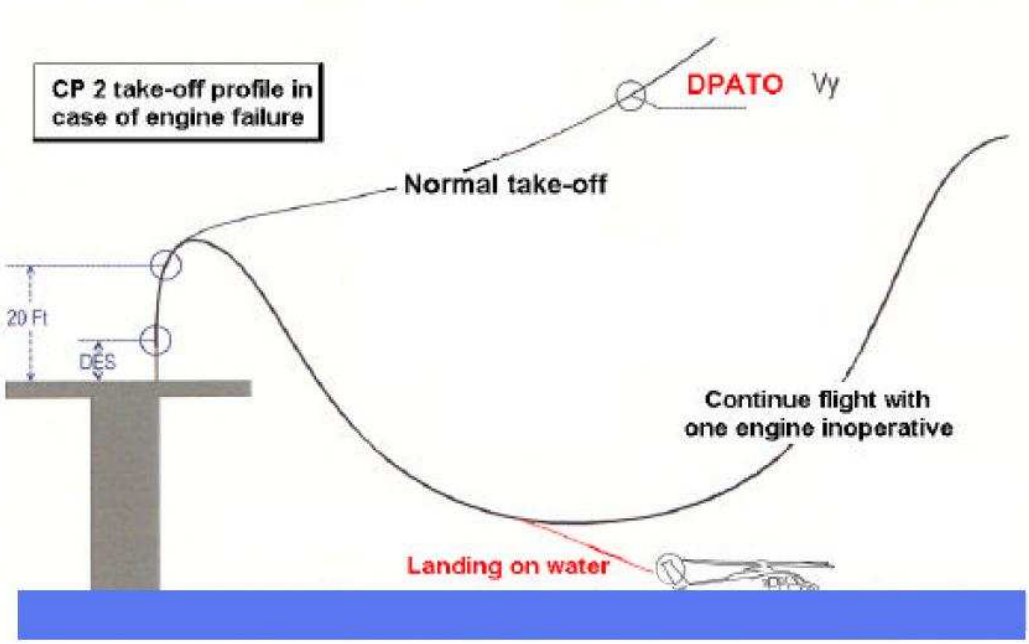
For Take Off – Non – Hostile Environment without an approval to operate with an exposure time, if an engine failure occurs, procedures are described enabling a safe landing or a safe forced landing whatever the phases of take off.

It prescribes also for "*Take Off – Non-Hostile Environment with exposure time": If an engine failure occurs after the exposure time and before DPATO, compliance with 3.520(a)(3) will enable a safe force landing on the surface. At or after the DPATO, the OEI flight path should clear all obstacles by the margins specified in OPS3.525*. There are no procedures described for engine failure before the end of exposure time.



1.17.4.3) Engine failure during take off in PC2 - Operation manual

The procedure of an engine failure during take off on a platform over water helideck describes that in case of a failure during or after cyclic input the pilot must set a nose down attitude of approximately 22° in order to avoid any contact between the rear of the helicopter and the edge of the platform. Cf appendix K (S76C++ operation Manual, part B, sect 2.1, page-27)



1.18 Additional information

1.18.1 Testimony of the pilot

The pilot explains that he took off from Kanbauk at about 9h local time with 7 passengers on board. He landed on the FSO helideck located 60 nautical miles out. The height of the helideck is estimated to be 50 feet. A passenger disembarked, with the rotor turning and 3 passengers boarded.
The FSO was oriented on a 215° heading, the wind was from 215° at 13 kt. The pilot hovered on a 125 heading before the takeoff. Then he climbed vertically to

30 feet and took off. Immediately after this, an aural warning sounded and engine out warning was illuminated. The pilot noticed an increase in the left T5 temperature, in the red zone at 983°, while the rig ht T5 remained in the green zone. The pilot felt the helicopter drop, a loss of power and a clanking noise. Because of the low height of the helicopter in relation to the water, the pilot decided to ditch in the sea. He initiated flotation devices deployment while the aural warning was cut off by the co-pilot. Helicopter contact with the sea was rather hard but the ditching took place without any problem. Then the helicopter tilted over 180° onto its left side.

1.18.2 Testimony of the first witness

FSO Helicopter landing officer (HLO) stated that, F-HJCS landed safety on FSO at 10:13 hrs. After a passenger disembarked and three passenger boarded, helicopter took off at 10:19 hrs. Helicopter hovered and move forward to the port side of FSO. He saw black smoke coming from the starboard side engine compartment and heard loud noise, immediately he radio contact to the FSO control room reported about accident. The helicopter fell towards the sea approximately 50 meter away from the FSO port side and floats inflated before touched the sea. He saw helicopter main rotor blades broken away. Eleven people come out from helicopter after 15 seconds and he maintained visual contact with the people in the water and threw life buoys.

1.18.3 Testimony of the second witness

FSO safety/Medic officer stated that after he saw helicopter accident, informed to central control Room and raised alarm emergency situation. He mustered at Emergency rescues team (ERT) and proceeded to rescue. Life rafts of helicopter were floated on the water and crews and passengers were floating around. He instructed ERT team to throw life buoys. He and ERT team wait for instruction from offshore installation Manager (OIM) on the life boat. FSO crew picked up one passenger using ladder, two passengers were sitting on the export hose and some were boarding in the drifting life raft. Then stand by vessel launched first operation. After he checked three unconscious casualty, found zero blood pressure with no heart beat and respiration, so he did cardio pulmonary resuscitation about (15-20) minutes. All crews and passenger were recued but three casualties were dead of drowning and two casualties were suffered severe back pain. All were sent ashore by Medivace helicopters.

1.18.4 Testimony of the third witness

One of the passengers stated that helicopter took off as usual straight up (approximately 10 meters above), then engine speed up and fly forward. Suddenly engine noise stopped and helicopter ditched into the sea near FSO. Before the helicopter ditch down, the pilot manage to say "Braise" and then helicopter ditched in to sea and tilted. Water poured into the cockpit, and he found exit door and got out of the chopper. He pull up life jacket and swan away, after then a supply boat came and rescued passengers.

ANALYSIS

The pilot performed a CP2 with exposure time take off from the FSO Helideck. At 25 feet over the helideck, while the pilot had begun a cyclic input, the right Engine Out warning light illuminated and the engine #2 flamed out. He decided to continue in order to ditch. He pushed the cyclic for a pitch down attitude in order to avoid the tail to strike on the platform edge. Then he initiated the floating devices and ditched. The helicopter capsized immediately after contact with the sea surface. All occupants evacuated from the helicopter. The rescue team arrived after 30 minutes and three of the occupants passed away from drowning.

1) Engine examination

After recovery of the wreckage, the engines were examined at Turboméca facilities. The first results indicated the rupture of a HP turbine blade on #2 engine. This rupture phenomenon, identified since 2007, is the subject of corrective action by Turboméca through modification TU166. However, **the increase in the cases of failures in 2011 led the BEA to issue a safety recommendation in order to suspend operations of Sikorsky S76C++ equipped with Arriel 2S2 engines in performance class 2 with exposure time as long as their engines had not been modified with TU166 ..see** appendix ..I**. (BEA recommendation from F-HJCS report)**

2) TDP – Rotation point - Procedure in case of engine failure

During takeoff in category A from a helideck, the Sikorsky S76C++ flight manual defines TDP (take off decision point) as a height of 30 feet above the helideck. In case of failure of one of the engines below TDP, the pilot must land on the helideck. Beyond the TDP, the pilot must take into account the meteorological conditions and the height of the helideck in order to deduce from it the value of the resulting dropdown and consequently the maximum takeoff weight to continue the flight.

The instruction of 21 March 2011 provides interpretations and explanations for the application of OPS 3 of 21 March 2011. The ACJ relating to procedures for the use of a helicopter from a helipad does not refer to the TDP as defined by the manufacturer. A point designated as “rotation point” is the reference without being defined. Its value is variable according to the type of helicopter.

The IEM OPS 3.520 relating to takeoff procedures without precise exposure time states that if a failure occurs during climb up to the rotation point, a safety landing or an emergency landing on the helideck is planned. Concerning takeoffs with exposure time, there is no specific procedure in case of a failure before the rotation point.
It is indicated that an emergency landing for safety reasons may not be possible in these conditions.

The Héli Union operations manual, approved by the DGAC, makes no reference to the TDP nor to the rotation point in its description of the procedure for engine failure during takeoff from a helideck. However, the illustration indicates a height of 20 feet above the helideck.
The references and values in the operations manual should not be lower than those certified by the manufacturer.
The absence of any cohesion in the definition of the reference points and associated values leads to the development of erroneous procedures, source of confusion for crews.

MAIB and the BEA recommend that DGAC ensure that its operators precisely define in their procedures and pilot training the different reference points used during helicopter take off operations in performance class 2 with exposure time.

3) Data and information available for eligibility

In June 2009 the DGAC informed Héli Union that the Sikorsky S76C++ helicopter was eligible to exposure time in relation to the statistics supplied by the manufacturer for the period 2003-2007.
The European regulation obliges operators to provide statistics to their respective national authorities. In practice, this is rarely respected since it is the national authority that takes steps through the manufacturer to recover the data that it needs to update the eligibility list.
At the end of 2011 the DGAC finally received data from the manufacturer for the period 2005-2009 after having asked several times.
In addition, the failure to release updated statistics within a reasonable time period makes it impossible for the national authorities to rule on the continuation or the suspension of eligibility for a helicopter type.

MAIB and BEA recommend that

- **EASA modify paragraph 1 ACJ-1 appendix 1 JAR-OPS3 3.517 (a) so that, prior to granting an approval, the operators provide validated power plant reliability statistics for the previous 5 year moving window.**
- **DGAC transpose into national regulations the changes made by EASA to paragraph 1 ACJ-1 annexe 1 JAR OPS 3.**

MAIB and BEA recommend that

- **EASA modify paragraph 4 ACJ-1 appendix 1 JAR-OPS3 3.517 (a) in order to introduce a reasonable time period (annually for example) of periodically reassessed updated statistics.**
- **DGAC transpose into national regulations the changes made by EASA to paragraph 4 ACJ-1 annex 1 JAR OPS 3.**

The separation between the authorities responsible for operational oversight and continuing airworthiness does not enable a coordinated and immediate corrective action.

The helicopter and the engine manufacturers supply EASA with information relating to continuing airworthiness of the helicopter.
The European organisation in charge of continuing airworthiness was apparently informed of all of the occurrences to Arriel 2S2 engines.
The helicopter and the engine manufacturers also provide statistics for risk assessment to the national authorities in order to determine the type of operations to be undertaken by operators.
The national authority was not aware of the occurrences.
Considering the increasing number of in-flight engine shutdowns due to the failure of a HP blade as well as the increasing number of blades with cracks, and this despite the corrective action taken since 2009 (modification TU166) and the decrease in the number of engines to retrofit, the organisation responsible for continuing airworthiness should have alerted the authorities in charge of operational oversight.

MAIB and BEA recommend that EASA study a method for release of information to the national authorities regarding sudden power loss rates of which it is aware and as soon as these rates get close to acceptable limits or show significant evolution.

4) Survivality

Although the Yetagun platform and the FSO are subject to the application of an ERP, the emergency procedures were not followed properly. According to the procedures, the FSO should have immediately made a Zodiac or the Starboard lifeboat available as the field stand-by boat was not in the vicinity of the FSO.

Consequently, MAIB recommends that the national authorities encourage the implementation of the procedures described in the ERP.

CONCLUSIONS

Findings

- The helicopter was certified, equipped and maintained in accordance with existing regulations and approved procedures.
- The flight crew were properly licensed and qualified to conduct the flight.
- Héli-Union holds a valid AOC.
- The operations manual describes procedures in case of engine shutdown.
- One engine flame out.
- The pilot made an emergency landing (ditching).
- The helicopter capsized after contact with the water.
- All crew members and passengers evacuated.
- All crew members and passengers boarded a life boat after 30 minutes.
- Two passengers and the co-pilot drowned.
- The wreckage was recovered on 26 November, 138 days after the accident.
- Both engines were examined on 15 and 16 December.

- The examination performed on the two engines determined an engine #2 in-flight shutdown.
- The in-flight shutdown was due to a failed HP turbine blade.
- The blade failure phenomenon had been identified in 2007.
- Corrective action was current through the TU166 modification.This modification was mandated by EASA on single-engine applications, and monitored by EASA on twin-engine applications.
- The F-HJCS helicopter had not been retrofitted.

Causes

- The accident originated from engine n°2 failure.
- The take-off procedure in performance class 2 with exposure time (in all take-off/ landing conditions) does not guarantee a safe emerge forced landing.

RECOMMENDATIONS

- The increase in the cases of failures in 2011 led the BEA to issue a safety recommendation in order to suspend operations of Sikorsky S76C++ equipped with Arriel 2S2 engines in performance class 2 with exposure time as long as their engines had not been modified with TU166.

- MAIB and the BEA recommend that DGAC ensure that its operators precisely define in their procedures and pilot training the different reference points used during helicopter take off operations in performance class 2 with exposure time.

- MAIB and BEA recommend that

  - EASA modify paragraph 1 ACJ-1 appendix 1 JAR-OPS3 3.517 (a) so that, prior to granting an approval, the operators provide validated power plant reliability statistics for the previous 5 year moving window.
  - DGAC transpose into national regulations the changes made by EASA to paragraph 1 ACJ-1 annexe 1 JAR OPS 3.

- MAIB and BEA recommend that

  - EASA modify paragraph 4 ACJ-1 appendix 1 JAR-OPS3 3.517 (a) in order to introduce a reasonable time period (annually for example) of periodically reassessed updated statistics.
  - DGAC transpose into national regulations the changes made by EASA to paragraph 4 ACJ-1 annex 1 JAR OPS 3.

– After the OEI 2 min indicator light flashes, select OEI continuous.
– Continue the climb.

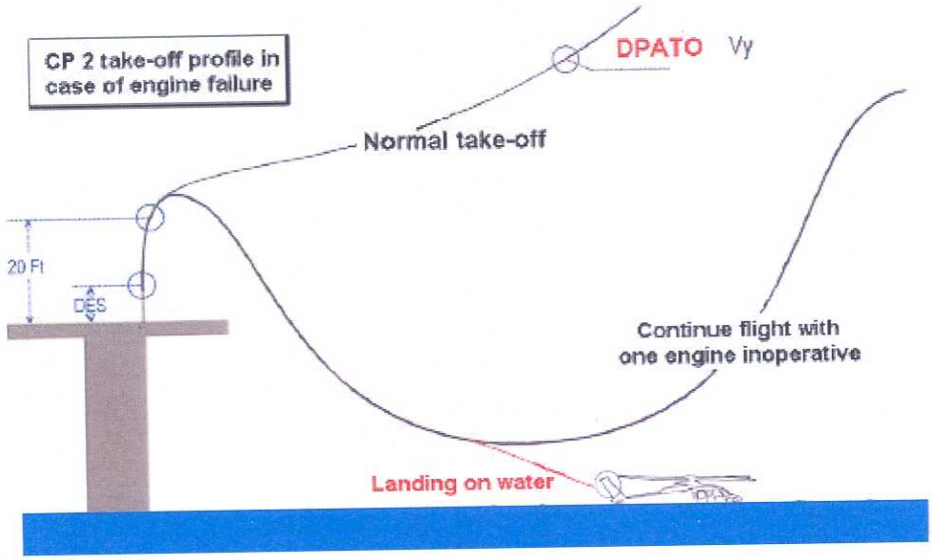
Note: During all these procedures, maintain "no air skid".

At 500 feet minimum:

PNF & PF – Shut down or re-start the failed engine according to the defined procedure.

PIC – **LAND AS SOON AS PRACTICABLE.**

245 FAILURE ON TAKE-OFF IN PC2, HELIDECK ON A PLATFORM OVER WATER



- Failure before cyclic input:

PF – **LAND IMMEDIATELY.**
– Cancel all lateral or longitudinal movement, and land flat on the helideck, vertically over the position.
– Control the landing as well as possible if the rotor speed decreases.
– Recentre the cyclic pitch lever.
– Completely lower the collective pitch and set the pedals to neutral.

PNF & PF – Shut down the helicopter and evacuate it if necessary.

- Failure during or after cyclic input:

Caution: *Very carefully monitor the "no air skid" which, during acceleration, will have an essential influence on: drag, torque, N1, T5, and consequently on: rotor rpm and acceleration.*

PF – Set a nose down attitude of approximately 22°, in order to avoid any contact between the rear of the helicopter and the edge of the platform, and build up speed.

SINGLE ENGINE FAILURE ON TAKEOFF – ELEVATED HELIDECK

The procedure to follow after an engine failure during a vertical takeoff depends on where in the takeoff sequence the failure occurs. If the engine fails before the TDP, the takeoff is rejected and the aircraft is landed on the helideck. The TDP is 30 ft above the takeoff surface. If the failure occurs after the TDP, the takeoff will be continued.

Rejected Takeoff

1. Sharply reduce collective to a mid-range position to minimize ballooning and excessive height.

2. With maximum height achieved and as aircraft begins to settle, increase collective to achieve 30-Second OEI power and allow rotor to droop to 104-106% N_r.

3. Keep the helideck in sight at all times and adjust position as necessary with cyclic to control a vertical descent to the landing surface.

WARNING

Crosswind can cause large horizontal repositioning at the apex of the reject. Anticipate this effect and correct as required.

4. Maintain 104 to 106% N_r, fixed collective, and accept the resultant vertical descent to the helideck.

5. When closure rate and altitude dictate that contact with the landing surface is imminent, apply collective at a rate and amount sufficient to cushion the landing. A slow, gradual collective input applied at excessive altitude must be avoided.

6. Upon ground contact, lower collective slightly to prevent excessive rotor droop, neutralize cyclic position, then continue lowering collective smoothly.

7. Floats – OFF.

Continued Takeoff

1. Continue nose down pitch rotation to 22° ± 2° nose down pitch attitude in 2 or less seconds.

2. Hold collective fixed initially and then reduce as necessary to arrest droop at 94% ± 2% N_r. Do not allow rotor speed to droop below 91% N_r.

Ministère
de l'Écologie,
du Développement
durable,
des Transports
et du Logement

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RÉPUBLIQUE FRANÇAISE

BEA
Bureau d'Enquêtes et d'Analyses
pour la sécurité de l'aviation civile

Le Bourget, 20 February 2012

European Aviation Safety Agency
Mr Patrick GOUDOU
Executive Director
Postfach 10 12 53
D 50452 Köln
Germany

N° FRAN-2012-002
Objet : accident to Helicopter Sikorsky S76C++ F-HJCS

Dear Patrick,

On 11 July 2011 the Sikorsky S76C++ helicopter registered F-HJCS went down in the Andaman Sea (Myanmar) following an engine failure on takeoff. The helicopter then overturned on contact with the water. Three occupants among the eleven persons on board died from drowning.
The wreckage of the helicopter was recovered in November 2011 and an examination of the engines was performed at Turboméca facilities on 14 and 15 December 2011.
The first results brought to light the failure of a blade in the HP turbine. This phenomenon, identified since 2007, is currently the subject of corrective action by Turboméca through the TU166 modification.

Alert letter n°2539/07/ARRIEL2/25 version 7 of 28 July 2010, service letter n°2784/10/AR2S version 1 of 19 November 2010 and service bulletin n°292 72 2166 version F of 13 May 2011 state how to apply this modification.

As of today, operators that wish to operate their helicopters in performance class 2 with exposure time to an engine failure during takeoff and landing phases must obtain an authorisation from the competent authority[1].
In the context of the risk study required to obtain the authorisation, operators must supply failure statistics for propulsion units for the type of helicopter and engine used. The statistics must show that the rate of engine shutdowns in flight does not exceed 1 per 100,000 hours of engine function over a sliding period of five years[2].
The authority authorizes operations by registering the aircraft involved on an « eligibility list ».

In relation to the Arriel 2S2 engines exclusively equipping the Sikorsky S76C++ helicopters, the BEA has noted that the engine manufacturer 's data for the 2007-2011 period showed an engine failure rate of 0.85 per 100,000 hours of flight. This rate, which is lower than the maximum value of 1 per 100,000, only takes into account failures that are caused by the engine, without considering those that may result from other parts of the helicopter.

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BEA

However, for the year 2011 alone, 4 cases of engine shutdowns in flight have been registered, one of which was the cause of this accident.

Although the real failure rate has not yet been determined for this period by the manufacturer, the BEA estimates that there is a potential risk of a failure in the critical phases of flight, in particular takeoff and landing. Around 80% of the engines have been modified up to now and the remaining ones should be dealt with by the end of 2012.

In the meantime:

The BEA recommends that EASA and the FAA take the necessary steps in order to suspend operations of Sikorsky S76C++ helicopters equipped with Arriel 2S2 engines in performance class 2 with exposure time as long as their engines have not been subject to modification TU166.

Regards

Le Directeur du BEA

Jean-Paul TROADEC

[1] In accordance with appendix 1 to paragraph OPS 3.517 (a).
[2] A higher rate not exceeding 3 per 100,000 hours of functions could be accepted by the authority after an evaluation showing an improvement.

SUBPART H – PERFORMANCE CLASS 2

JAR-OPS 3.515 General

(a) An operator shall ensure that [ ] helicopters operated in Performance Class 2 are certificated in Category A [see also ACJ to JAR-OPS 3.480(a)(1) and (a)(2))].

[ ]

[Ch. 1, 01.02.99; Amdt. 5, 01.07.07]

JAR-OPS 3.517 [Operations Without an Assured Safe Forced Landing Capability

(a) An operator shall be satisfied that operations without an assured safe forced landing capability during the take-off and landing phases are not conducted unless the operator has been granted the relevant approval by the Authority in accordance with Appendix 1 to JAR-OPS 3.517(a). (See also JAR-OPS 3.470(a)(1).)]

[ ]

[Ch. 1, 01.02.99; Amdt. 2, 01.01.02; Amdt. 5, 01.07.07]

JAR-OPS 3.520 Take-off
[(See ACJ to Subpart H)]
(See IEM-OPS 3.520 & 3.535)

(a) An operator shall [be satisfied] that:

(1) The take-off mass does not exceed the maximum mass specified for a rate of climb of 150 ft/min at 300 m (1 000 ft) above the level of the heliport with the critical power unit inoperative and the remaining power units operating at an appropriate power rating.

(2) [For operations other than specified in JAR-OPS 3.517(a), the takeoff is conducted such that a safe forced landing can be executed until the point where safe continuation of the flight is possible (see ACJ to Subpart H paragraph 6.2).

(3) For operations in accordance with JAR-OPS 3.517(a) in addition to the requirements of (a)(1) above:

(i) The take-off mass does not exceed the maximum mass specified in the Helicopter Flight Manual for an AEO OGE hover in still air with all power units operating at an appropriate power rating.

(ii) For operations to/from a helideck:

(A) with a helicopter that has a maximum approved passenger seating configuration (MAPSC) of more than 19; and

(B) from 1st January 2010 any helicopter operated to/from a helideck located in a noncongested hostile environment as defined in JAR-OPS 3.480(13)(ii)(A)

the take-off mass takes into account: the procedure; deck-edge miss; and drop down appropriate to the height of the helideck - with the critical power unit(s) inoperative and the remaining power units operating at an appropriate power rating.

(b) When showing compliance with sub-paragraph (a) above, account shall be taken of the appropriate parameters of JAR-OPS 3.475(c) at the heliport of departure.

(c) The part of the take-off before the requirement of JAR-OPS 3.525 is met shall be conducted in sight of the surface.]

[ ]

[Ch. 1, 01.02.99; Amdt. 5, 01.07.07]

JAR-OPS 3.525 Take-off Flight Path
[(See ACJ to Subpart H)]

(a) [An operator shall be satisfied that from DPATO or, as an alternative, no later than 200 ft above the take-off surface, with the critical power-unit inoperative the requirements of JAR-OPS 3.495(a)(1), (2) and (b) are met.]

[ ]

[Ch. 1, 01.02.99; Amdt. 5, 01.07.07]

JAR-OPS 3.530 En-route - Critical power unit inoperative

(a) An operator shall ensure that [the requirement of JAR-OPS 3.500 is met.]

[ ]

[Ch. 1, 01.02.99; Amdt. 2, 01.01.02; Amdt. 5, 01.07.07]

Appendix 1 to JAR-OPS 3.517(a)
Helicopter operations [without an assured safe forced landing capability]

[(See JAR-OPS 3.517(a))]

[(See ACJ-1 to Appendix 1 to JAR-OPS 3.517(a))]

[(See ACJ-2 to Appendix 1 to JAR-OPS 3.517(a))]

(a) *Approval:*

(1) [Following a risk assessment, an operator may be authorised to conduct operations without an assured safe forced landing capability during the take-off and landing phases, under an approval specifying:]

(i) The type of helicopter; and

(ii) The type of operations.

(2) Such an approval will be subject to the following conditions:

(i) [A set of conditions to be implemented by the operator to obtain and maintain the approval for the helicopter type;

(ii) Implementation of a Usage Monitoring System]

[ ]

[Ch. 1, 01.02.99; Amdt. 5, 01.07.07]

ACJ-1 to Appendix 1 to JAR-OPS 3.517(a)

carried, such operations are permitted in PC 2 (JAR-OPS 3.470(a)(2)) but, in all helideck environments (both hostile and non-hostile), have to satisfy, the additional requirements, set out in 7.4.2 above.]

[Ch. 1, 01.02.99; Amdt. 5, 01.07.07]

[ ]

[Ch. 1, 01.02.99; Amdt. 5, 01.07.07]

[ ]

[Amdt. 5, 01.07.07]

[ ]

[Amdt. 5, 01.07.07]

[ACJ-1 to Appendix 1 to JAR-OPS 3.517(a)
Helicopter operations without an assured safe forced landing capability

1. As part of the risk assessment prior to granting an approval under Appendix 1 to JAR-OPS 3.517(a), the operator should provide appropriate powerplant reliability statistics available for the helicopter type and the engine type.

2. Except in the case of new engines, such data should show sudden powerloss from the set of in-flight shutdown (IFSD) events not exceeding 1 per 100,000 engine hours in a 5 year moving window. However, a rate in excess of this value, but not exceeding 3 per 100,000 engine hours, may be accepted by the Authority after an assessment showing an improving trend.

3. New engines should be assessed on a case-by-case basis.

4. After the initial assessment, updated statistics should be periodically reassessed; any adverse sustained trend will require an immediate evaluation to be accomplished by the operator in consultation with the Authority and the manufacturers concerned. The evaluation may result in corrective action or operational restrictions being applied.

5. The purpose of this paragraph is to provide guidance on how the in-service power plant sudden power loss rate is determined.

5.1. Share of roles between the helicopter and engine Type Certificate Holders (TCH).

a) The provision of documents establishing the in-service sudden power loss rate for the helicopter/engine installation; the interface with the operational Authority of the State of Design should be the Engine TCH or the Helicopter TCH depending on the way they share the corresponding analysis work.

b) The Engine TCH should provide the Helicopter TCH with a document including: the list of in-service power loss events, the applicability factor for each event (if used), and the assumptions made on the efficiency of any corrective actions implemented (if used);

c) The Engine or Helicopter TCH should provide the operational Authority of the State of Design or, where this Authority does not take responsibility, the operational Authority of the State of the Operator, with a document that details the calculation results - taking into account: the events caused by the engine and the events caused by the engine installation; the applicability factor for each event (if used), the assumptions made on the efficiency of any corrective actions implemented on the engine and on the helicopter (if used); and the calculation of the powerplant power loss rate,

5.2 Documentation The following documentation should be updated every year.

5.2.1 The document with detailed methodology and calculation as distributed to the Authority of the State of Design.

SAFRAN
Turbomeca

INVESTIGATION REPORT

Preliminary ☐
Final ☒

Accident ☒ **Incident** ☐

Reference	T12-CR0146A-3	Commercial File	N/A
Accident / Incident report	2011 / 199	Preliminary Information report A(I)	N/A

Data

Date of occurrence	Occurrence place	Operator
11th July 2011	Near Yetagun oil rig, Myanmar	Héli Union

Aircraft type	S/N	Registration
S76C++	760740	F-HJCS

Engine type	S/N	TSN	TSO
Arriel 2S2	42265	1186	N/A
Arriel 2S2	42266	1186	N/A

Accessories

Designation, P/N	S/N	Work performed	TSN	TSO
N/A				

Circumstances reported to TURBOMECA

During the take-off phase from a tanker, the pilot reported an audio warning accompanied by the illumination of the red "#1 ENGINE OUT" light. The crew had a clear sensation of power loss with descent and yaw jerk with an audible pop. The pilot noticed that the T5 of the left-hand engine reached 983°C. The floats were deployed and the aircraft ditched, but, due to the swell and windy conditions, it overturned onto the left side. The passengers evacuated the aircraft before it sank in 105 m deep water. 30 minutes later, the rescue team recovered the survivors and noticed that the copilot and two passengers were dead.
Witnesses on the tanker reported to have seen the presence of 2 big flames from the engine at the time of the accident.

Conclusion

Engine #1 (s/n 42266) was in very good condition and calculations showed that it was able to deliver OEI 30" power levels at the time of the accident.

One High Pressure (HP) turbine blade of Engine #2 (s/n 42265) was found ruptured below the platform. As a consequence, the other HP turbine blades and the Power Turbine blades were damaged above the platform. This rupture is similar to other previously analysed HP blade ruptures. This event explains the loss of power during take-off reported by the pilot and the flames at exhaust reported by witnesses.

VALIDATION		APPROVAL	
DATE	Validated by DVO/TEA	DATE	Approved by DVO/TEA
30 March 2012		30 March 2012	

Table of Contents

1 INTRODUCTION

1.1 GENERALITIES

Arriel 2S2 engines, serial numbers 42265 and 42266, were fitted to helicopter Sikorsky S76C++ registration F-HJCS which ditched and sank near the Yetagun Oil Rig off the coast of Myanmar, on 11th July 2011. The wreckage was recovered on 26th November 2011 and brought back to shore on 27th November 2011.

Consequently to the visual examination of the wreckage in Myanmar, the Myanmar investigation board, MAIB, requested the deep examination of the engines. They were removed from the wreckage and delivered in sealed containers to Turbomeca's facilities located in Tarnos, France. The investigation was performed on 14th, 15th and 16th of December 2011.

The engines' examination led to further laboratory investigations on selected turbine components. The investigation started early January 2012 at Turbomeca Bordes laboratory facilities and is expected to terminate end of February 2012.

Mr Xavier Azéma participated during the investigations as technical advisor to Mrs Laurence Bernard, Accredited Representative of the Bureau d'Enquêtes et Analyses pour la Sécurité de l'Aviation Civile (BEA), French investigation Board.

The purpose of this document is to provide a factual account of the work performed and of the findings obtained during the engines' investigation and to give a preliminary account of the turbine components' laboratory intermediate findings.

1.2 ATTENDEES

The following entities were represented during the investigations at Turbomeca :

- MAIB of the Department of Civil Aviation of the Union of Myanmar
- BEA of France
- Sikorsky of USA
- Héli Union with representatives from France and Myanmar operations
- Turbomeca of France

1.3 GLOSSARY

CVFDR	Cockpit Voice and Flight Data Recorder
DECU	Digital Engine Control Unit
HP	High Pressure Turbine
NG	Gas generator speed of rotation
NGV	Nozzle Guide Vane
NR	Main Rotor speed of rotation
NTL	Power Turbine speed of rotation
P0	Ambient air pressure
T0	Ambient temperature
TSN	Time Since New
TSO	Time Since Overhaul

2 BACKGROUND

2.1 FIELD INVESTIGATION RESULTS

During the examination in Myanmar, the aircraft and the engines appeared in good general condition except for deposits due to the prolonged amount of time spent under water.

Engine #1 (s/n 42266) did not exhibit any pre-accident damage with no particular findings to report.

The examination of engine #2 (s/n 42265) revealed damages to the blade tips of both the High Pressure Turbine and of the Power Turbine. No other significant findings were found on engine #2.

The aircraft's cockpit examination revealed that the shut-off valve of engine #1 had been activated and that it was in the "OFF" position. The fuel lever of engine #2 was in the direct "DIR" position and the pilot control lever was in the flight position.

The maintenance documentation review showed that both engines had positive power margins a few days prior to the accident.

2.2 UPDATED CIRCUMSTANCES

For the day of the accident :
T0 = 28°C
P0 = 1,006 hPa

The memorized contents of the CVFDR were downloaded and analysed at BEA's premises on 19th and 20th December 2011.

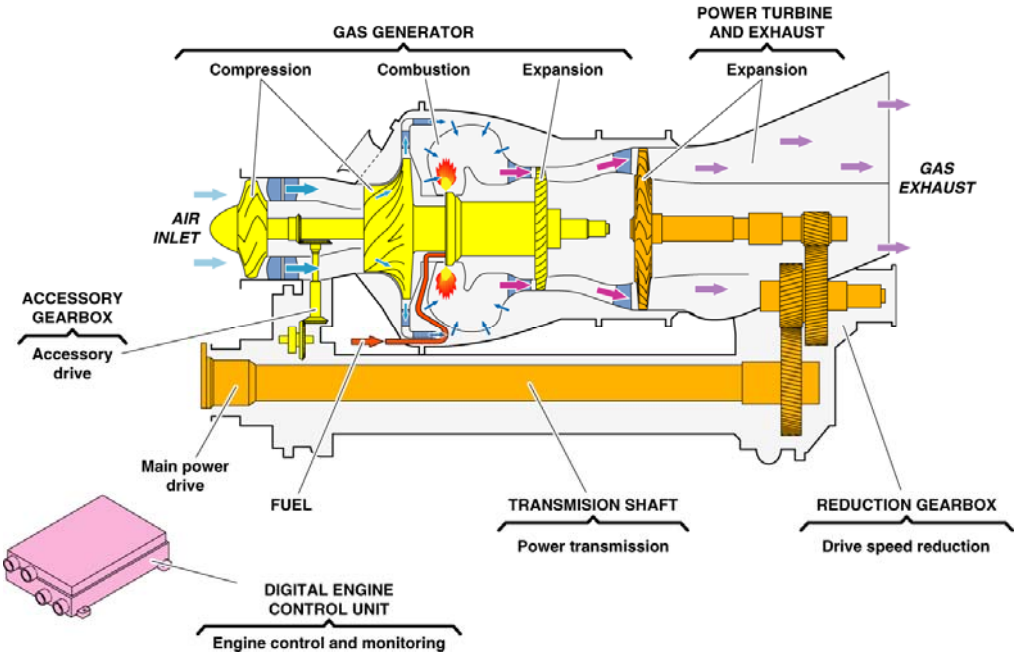
The analysis of the CVFDR data revealed that the helicopter was in a hover 25 ft above the oil tanker's helideck when engine #2 lost power. The readings indicated that the "ENG 2 OUT" signal was recorded and that engine #1's torque immediately climbed to 120 % and then increased further to 140 % during the following seconds.

NR started dropping as soon as engine #2 lost power and fell to 70% when the recordings stopped approximately 4 seconds later.

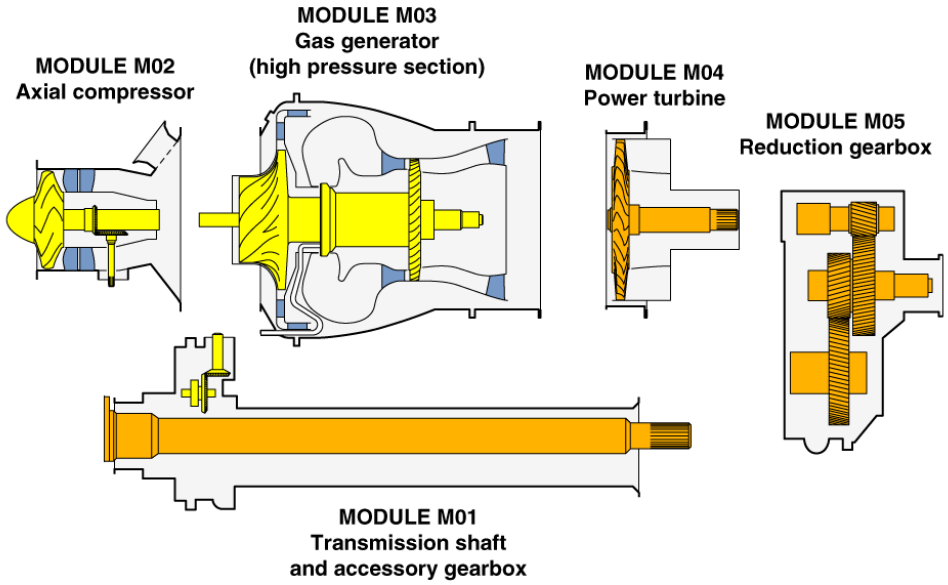
The contents of the DECUs' memory chips were not recovered because of their poor condition due to the time spend under water.

2.3 ARRIEL 2S2 ENGINE GENERALITIES

The Arriel 2S2 engine is a turboshaft engine with a single-stage axial compressor, a single-stage centrifugal compressor, an annular combustion chamber, a single stage high pressure turbine, a single stage power turbine, and a reduction gearbox with a nominal output at 6,400 rpm.



The engine is composed of 5 modules :



The engine is rated at 923 shp (688 kW) at takeoff power and 833 shp (629 kW) at maximum continuous power.

The dimensions of the engine are 1.12 m long, 0.412 m wide, and 0.609 m tall. Its dry weight is 126 kg.

The ignition system is one of low tension, high energy, and includes one high-energy generator, two injectors, and two igniters. Engine start is via an electrovalve.

3 INVESTIGATION REVIEW

3.1 GENERALITIES

The investigation consisted in removing the engines' dressing and equipment. Due to the time spent under water, the electrical connectors were seized and the removal of the harnesses was only possible after cutting the wires.

Once undressed, both engines could be separated into modules. For both engines, the modules 4 (power turbine) and module 5 (reduction gearbox) could not be separated. They stuck together because of the time spent under water.

3.2 ENGINE #1 EXAMINATION

3.2.1 Technical Documentation

Modular composition:

Engine	TSN	TSO	Remarks
Arriel 2S2 – S/N 42266	1186	N/A	
Modules	**Part Number**	**Serial Number**	**Remarks**
M01 – Accessories Gearbox	70BM017800	7097	
M02 – Axial Compressor	70BM027800	7897	

M03 – Gas Generator	70BM037800	10490	
M04 – Power turbine	70BM041750	7362	
M05 – Reduction Gearbox	70BM057800	11397	

3.2.2 Findings on arrival

The container was security sealed and had not been opened since its dispatch from Myanmar

The container contained the dressed engine, the output drive shaft, the main gearbox input gear and the engine log book.
The log book contained all the sections except the modules and equipment log cards which were provided by the Héli-Union representative.

The engine was wrapped in a waterproof wrapping which, once opened, revealed the complete engine.

3.2.3 Engine disassembly

3.2.3.1 MODULE 1 – ACCESSORIES GEARBOX

The accessories gearbox was in good condition.

The casings were partially covered with a white soft material which was a consequence of the time spent under water.

3.2.3.2 MODULE 2 – AXIAL COMPRESSOR

The axial compressor was in good condition. Some blades were locally covered with a white soft material which was a consequence of the time spent under water. The blades did not display any visible impact marks or warping.

The casings were partially covered with a white soft material which was a consequence of the time spent under water.

3.2.3.3 MODULE 3 – GAS GENERATOR

The gas generator was stripped to reveal the centrifugal compressor and the High Pressure turbine.

Centrifugal compressor :

The centrifugal wheel exhibited light rubbing traces across the blades' top edges. The blades did not exhibit any abnormal warping or any loss of material and did not show any impacts or wear on the leading and trailing edges.

The compressor front cover exhibited a small puncture at the 6 O'clock position near the front of the cover. The hole was approximately 10mm in diameter with rubbing marks around it.

The compressor front cover exhibited several local rubbing marks at inlet and outlet levels. The cover's inner surface exhibited a series of narrow marks left by the centrifugal wheel's blades during its time under water.

High Pressure turbine and combustion chamber :

The HP turbine wheel was in very good condition. All the blades were in position and showed no traces of rubbing or warping.

Similarly, the HP turbine shroud was also in good condition.

The parts were were locally covered with a white soft material which was a consequence of the time spent under water.

For the HP turbine laboratory investigation, please refer to § 3.2.4 below.

3.2.3.4 MODULE 4 – POWER TURBINE

The Power Turbine module stuck to the Module 5 reduction gearbox because of the time spent under water and they could not be taken apart. Nevertheless, they could be separated from the gas generator to reveal the power turbine wheel and nozzle guide vane. Both items were in very good condition with no traces of damage or rubbing.

3.2.3.5 MODULE 5 – REDUCTION GEARBOX

The reduction gearbox could not be separated from the Module 4 Power Turbine and was not opened. Its casings appeared in good condition and were locally covered with a white soft material which was a consequence of the time spent under water.

3.2.4 HP turbine (s/n 10365UP) laboratory analysis

The HP turbine wheel assembly was analysed in Turbomeca's Bordes laboratory. All the blades and the disk were checked with dye penetrant inspection that did not reveal any cracks.

3.3 ENGINE #2 EXAMINATION

3.3.1 Technical Documentation

Modular composition:

Engine	TSN	TSO	Remarks
Arriel 2S2 – S/N 42265	1186	N/A	
Modules	**Part Number**	**Serial Number**	**Remarks**
M01 – Accessories Gearbox	70BM017800	7093	
M02 – Axial Compressor	70BM027800	7893	
M03 – Gas Generator	70BM037800	10486	
M04 – Power turbine	70BM041750	7356	
M05 – Reduction Gearbox	70BM057800	11393	

3.3.2 Findings on arrival

The container was security sealed and had not been opened since its dispatch from Myanmar.

The container contained the dressed engine, the output drive shaft, the main gearbox input gear and the engine log book.
The log book contained all the sections except the modules and equipment log cards which were provided by the Héli-Union representative.

The engine was wrapped in a waterproof wrapping which, once opened, revealed the complete engine.

3.3.3 Engine disassembly

3.3.3.1 MODULE 1 – ACCESSORIES GEARBOX

The accessories gearbox was in good condition.

The casings were partially covered with a white soft material which was a consequence of the time spent under water.

3.3.3.2 MODULE 2 – AXIAL COMPRESSOR

The axial compressor was in good condition. Some blades were locally covered with a white soft material which was a consequence of the time spent under water. The blades did not display any visible impact marks or warping.

The casings were partially covered with a white soft material which was a consequence of the time spent under water.

3.3.3.3 MODULE 3 – GAS GENERATOR

The gas generator was stripped to reveal the centrifugal compressor and the High Pressure turbine.

Centrifugal compressor :

The centrifugal wheel exhibited light rubbing traces across the blades' top edges. The blades did not exhibit any abnormal warping or any loss of material and did not show any impacts or wear on the leading and trailing edges.

The compressor front cover exhibited several local rubbing marks at inlet and outlet levels. The cover's inner surface exhibited a series of narrow marks left by the centrifugal wheel's blades during its time under water.

Combustion chamber :

The combustion chamber was in good condition and was locally covered with a white soft material which was a consequence of the time spent under water.

High Pressure turbine :

The HP turbine wheel had one blade broken below its platform near the top of the fir tree root. All the other blades were normally positioned on the disk and exhibited impact damage and material loss above their platforms.

The HP turbine shroud and the trailing edges of the Nozzle Guide Vane's (NGV) vanes exhibited impact marks indicative of multiple collisions with the blades' debris.

The parts were locally covered with a white soft material which was a consequence of the time spent under water.

The HP turbine wheel and the shroud were sent to Turbomeca's Bordes laboratory for deeper investigation.

For the HP turbine wheel and shroud laboratory investigations, please refer to § 3.3.4 below.

3.3.3.4 MODULE 4 – POWER TURBINE

The Power Turbine module stuck to the Module 5 reduction gearbox because of the time spent under water and they could not be taken apart. Nevertheless, they could be separated from the gas generator to reveal the power turbine wheel and nozzle guide vane.

The NGV vanes' trailing edges exhibited impact marks.

The Power Turbine blades were normally positioned on the disk. They exhibited impact damage and material loss above their platforms.

This level of damage resulted from the HP turbine blades' debris being sent down the air path and colliding with the Power Turbine blades'.

3.3.3.5 MODULE 5 – REDUCTION GEARBOX

The reduction gearbox could not be separated from the Module 4 Power Turbine and was not opened. Its casings appeared in good condition and were locally covered with a white soft material which was a consequence of the time spent under water.

3.3.4 HP turbine components' laboratory analysis

3.3.4.1 HP TURBINE WHEEL (S/N 10325UP)

The HP turbine wheel assembly was analysed in Turbomeca's Bordes laboratory. It was subjected to the following tests :

- Visual examination

The visual examination identified the fatigue rupture of blade # 6 below the platform.

Localised tear of the disk's upper fir tree root as a consequence of the blade rupture.

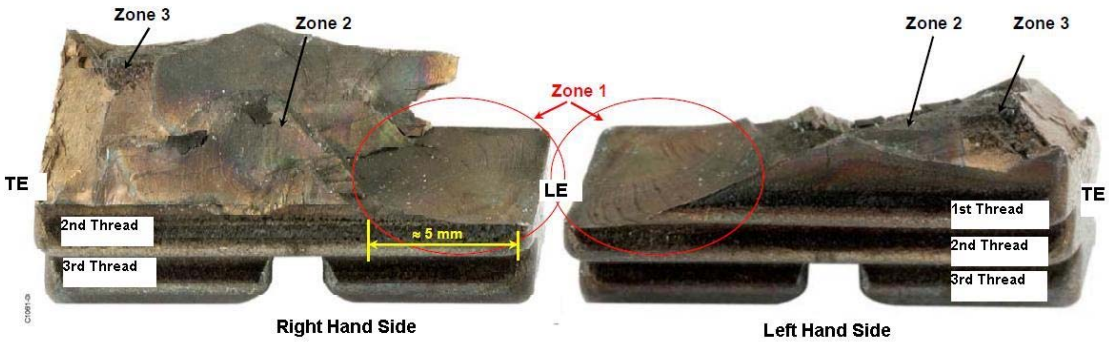
Damages to the other blades above the platform were consecutive to the rupture of blade #6.

No axial movement of any of the blades.

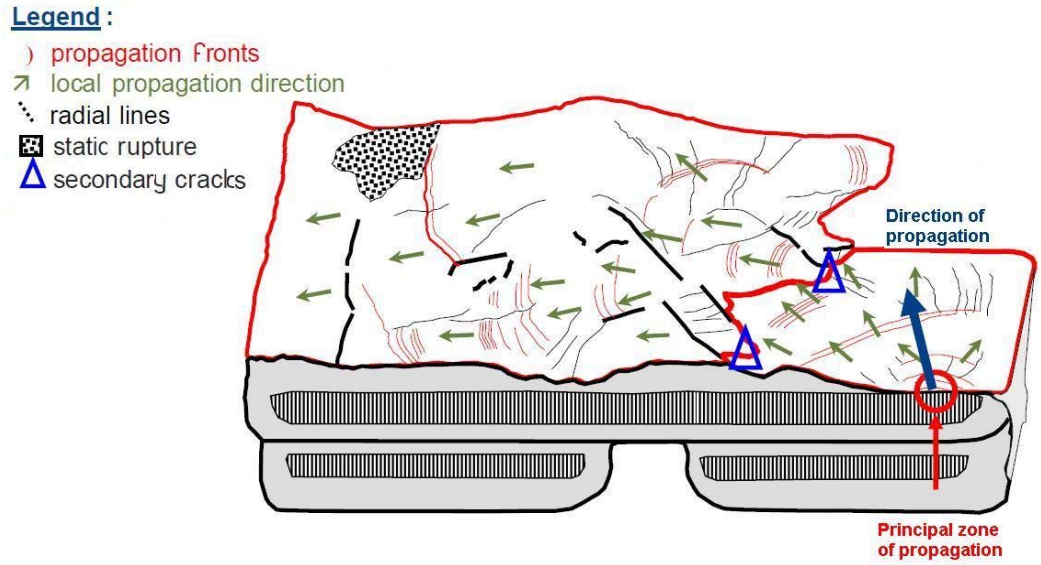
No pollution other than the presence of salt due to the prolonged time spent by the engine under water.

- Fractographic examination of blade # 6

The fractographic examination focussed on the fracture surface.



Legend : TE = Trailing Edge
LE = Leading Edge

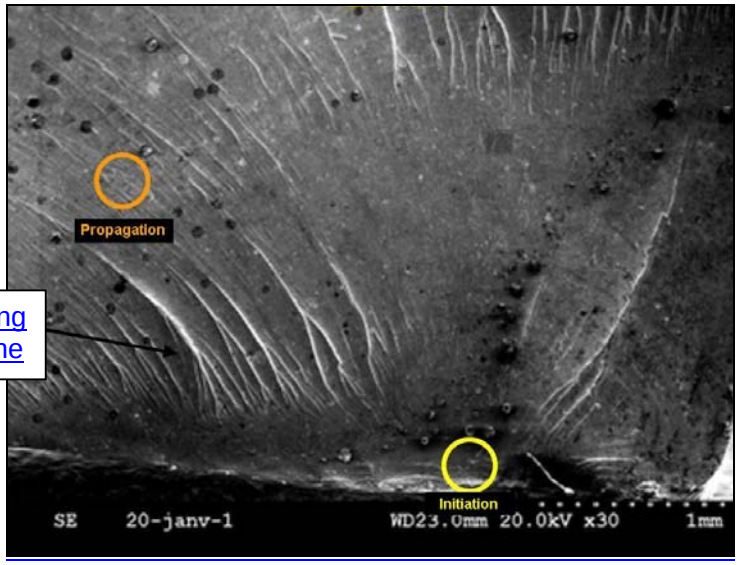


The fractured area was typical of a rupture by fatigue and was divided into three areas:

- First, a zone of initialisation near the leading edge of the blade and propagation in a plane towards the trailing edge.
- Second, a zone of propagation along crystallographic planes.

  (The first and second zones of propagation by fatigue represent 90% of the whole fracture surface)
- Third, a zone corresponding to the final rupture of the remaining section (approximately 10% of the total fracture surface).

The microfractographic examination of the first zone of the fracture area showed a succession of lines corresponding to the propagation of the crack.



Lines converging on initiation zone

No other cracks could be seen outside the fracture surface.

The examination of the contact surfaces of the blades' fir tree roots showed homogeneous zones of contact.

The general aspect of the fracture surface was very similar to that found during previous analyses performed in the frame of other HP blade ruptures.

o Non destructive testing

The dye penetrant inspection revealed microcracks in the areas of fir tree root contact between the blades and the disk. By experience, such microcracks do not necessarily lead to the rupture of the blade. They appear superficial with propagation in line with the wear of the contact surface.

The dye penetrant inspection on the blades' wire locks did not reveal any particular findings

o Natural frequency check

The manufacturing data was retrieved to check the blades' natural frequency when new. Blade # 6 was near the average frequency value.

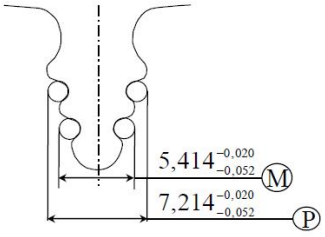
o Dimensional checks

The dimensional checks consisted in the measurement of the fir tree roots of selected blades and disk recesses which corresponded to the ruptured blade # 6, its two adjacent blades (# 5 and 7) and the diametrically opposed blade (# 25).

- Blades' dimensional checks :

The results for the blades' fir tree root widths were satisfactory as shown below :

N° Pale S/N	Position	M = 5,414 -0,020 / -0,052	P = 7,214 -0,020 / -0,052
39833	5	5,300 / 5,315	7,170
39765	6(1)	5,375	/(2)
39858	7	5,375	7,180
39874	25	5,370	7,175

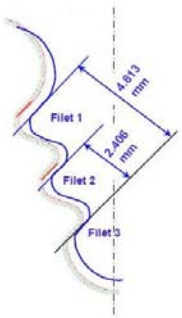


(1) – ruptured blade

(2) – not feasible : material missing due to the blade rupture

The results for the distance between threads produced values beyond the reference dimensions for blade # 5.

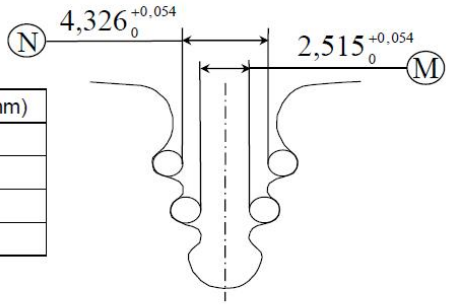
Dimension		Blade # 5	Blade # 6	Blade # 7	Blade # 25
4.8132 +/- 5µm	RH	+ 2 µm	Not feasible	+ 0 µm	-1 µm
	LH	+ 20 µm	Not feasible	- 5 µm	-3 µm
2.4066 +/- 5 µm	RH	+ 3 µm	Not feasible	+ 2 µm	+ 2 µm
	LH	+ 23 µm	Not feasible	-2 µm	+ 0 µm



Previous analyses in the frame of other HP blade ruptures have shown similar out-of-tolerance dimensions such as those found on blade # 5.

- Disk's recesses dimensional checks :

The results for the disk's fir tree root recesses widths were satisfactory as shown below :

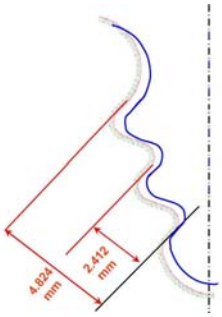


	M = 2,515 +0 / +0,054 (mm)	N = 4,326 +0 / +0,054 (mm)
Recess 5	2,670 / 2,580	4,480 / 4,390
Recess 6*	2,510	4,315
Recess 7	2,560 / 2,550	4,360
Recess 25	2,560	4,360

(*)– recess corresponding to the ruptured blade

The results for the distance between threads produced several values beyond the reference dimensions.

Dimension		Recess # 5	Recess # 6	Recess # 7	Recess # 25
4.824 +/- 5µm	TE RH / LH	-30 / +29 µm	-43 / -12 µm	-16 / -7 µm	-5 / -7 µm
	LE RH / LH	-35 / +53 µm	+0 / +3 µm	-17 / -10 µm	-12 / -9 µm
2.412 +/- 5 µm	TE RH / LH	+11 / -11 µm	+15 / -7 µm	-11 / -3 µm	-10 / -7 µm
	LE RH / LH	-13 / +32 µm	-24 / -11 µm	-8 / -6 µm	-2 / -4 µm

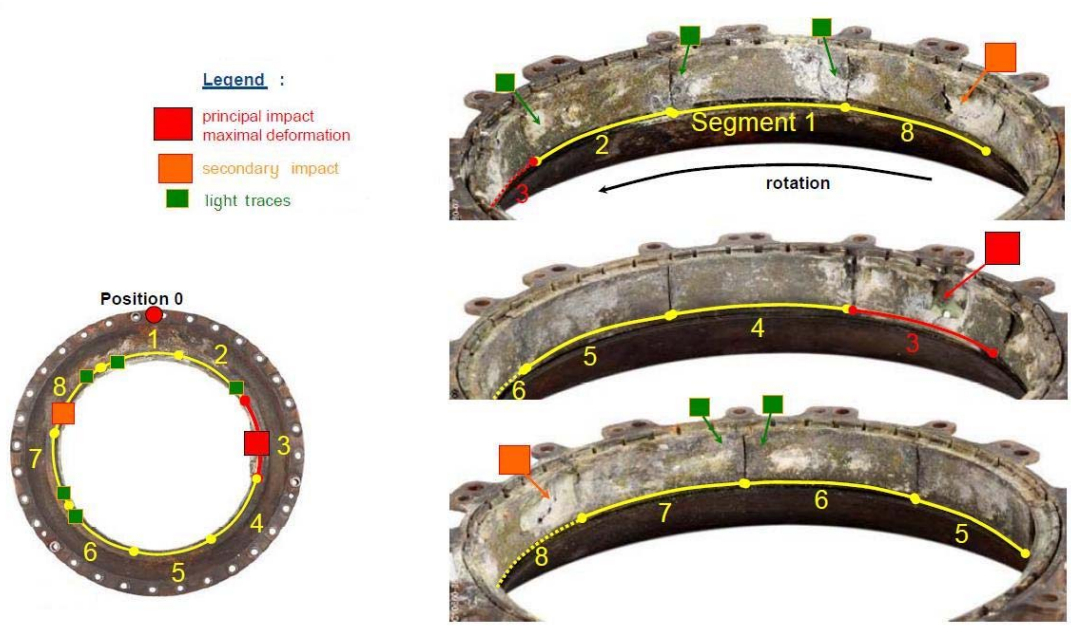


Previous analyses in the frame of other HP blade ruptures have shown similar out-of-tolerance dimensions on the disks' recesses.

3.3.4.2 HP TURBINE SHROUD

The HP turbine shroud was analysed in Turbomeca's Bordes laboratory.

The shroud exhibited one deep impact, located at the 3 O'clock position, corresponding to blade #6's rupture. The impact distorted the outer diameter of the shroud locally without leading to a puncture.



Another impact, less deep, was visible at the 10 O'clock position. Several other minor impacts could also be seen inside the shroud.

None of the impacts punctured the shroud.

4 ANALYSIS

The Arriel 2S2 engines s/n 42265 and s/n 42266 were returned to Turbomeca, Tarnos plant for deeper investigation. They were both undressed and separated into modules. Then both module 3 Gas Generators were disassembled to reveal their internal components.

- Engine s/n 42266 (position 1, Left Hand on the aircraft) :

  This engine was globally in very good condition. Local white soft deposits were indicative of the long amount of time it had spent under water.

  The only noticeable findings were on the centrifugal compressor that exhibited light rubbing marks and a puncture near the front of the cover. Such rubbing marks and puncture may be the result of important jerking movements imposed on the rotating assembly such as a previous hard landing, or the impact of the aircraft with the water and/or the ingestion of water when the aircraft capsized.

  The equally spaced narrow marks found on the compressor cover are indicative of the position of the centrifugal compressor blades that remained at standstill in the water after the aircraft sank.

  The HP and the Power Turbines were in very good condition. Moreover, by experience, a small puncture in the compressor cover does not have any significant impact on the engine's performance. This is consistent with calculations which indicated that this engine delivered the OEI 30" torque rating at the time of the accident : this engine delivered approximately 120% torque at the time of the engine #2 power loss which is higher than the 116% torque obtained with a theoretical calculation based on a minimum aged engine model with 3%

power margin (see Appendix).

- Engine s/n 42265 (position 2, Right Hand on the aircraft) :

This engine was externally in very good condition. Local white soft deposits were indicative of the long amount of time it had spent under water.

Once open, the centrifugal wheel and the compressor front cover showed several traces of light rubbing. Such rubbing marks may be the result of important jerking movements imposed on the rotating assembly and are consistent with the sudden loss of the HP turbine blade and of the important unbalance that ensued. The axial wheel and the centrifugal wheel did not display any visual impact marks or warping.

The equally spaced narrow marks found on the compressor cover are indicative of the position of the centrifugal compressor blades that remained at standstill in the water after the aircraft sank.

One blade of the HP turbine wheel was ruptured below its platform. –All the other blades were damaged above their platforms as a consequence. It also led to Power Turbine blades above platform damages. The subsequent laboratory investigation revealed that the rupture was due to fatigue propagation. This laboratory analysis produced results similar to other HP blade rupture analyses. This rupture explains the sudden loss of power during take-off as stated by the pilot and also the flames at the exhaust as stated by the witnesses on the tanker.

APPENDIX : ENGINE #1 S/N 42265 PERFORMANCE CALCULATIONS

Helicopter F-HJCS Accident

Engine s/n 42266 performance estimates

(RA 2011/199)

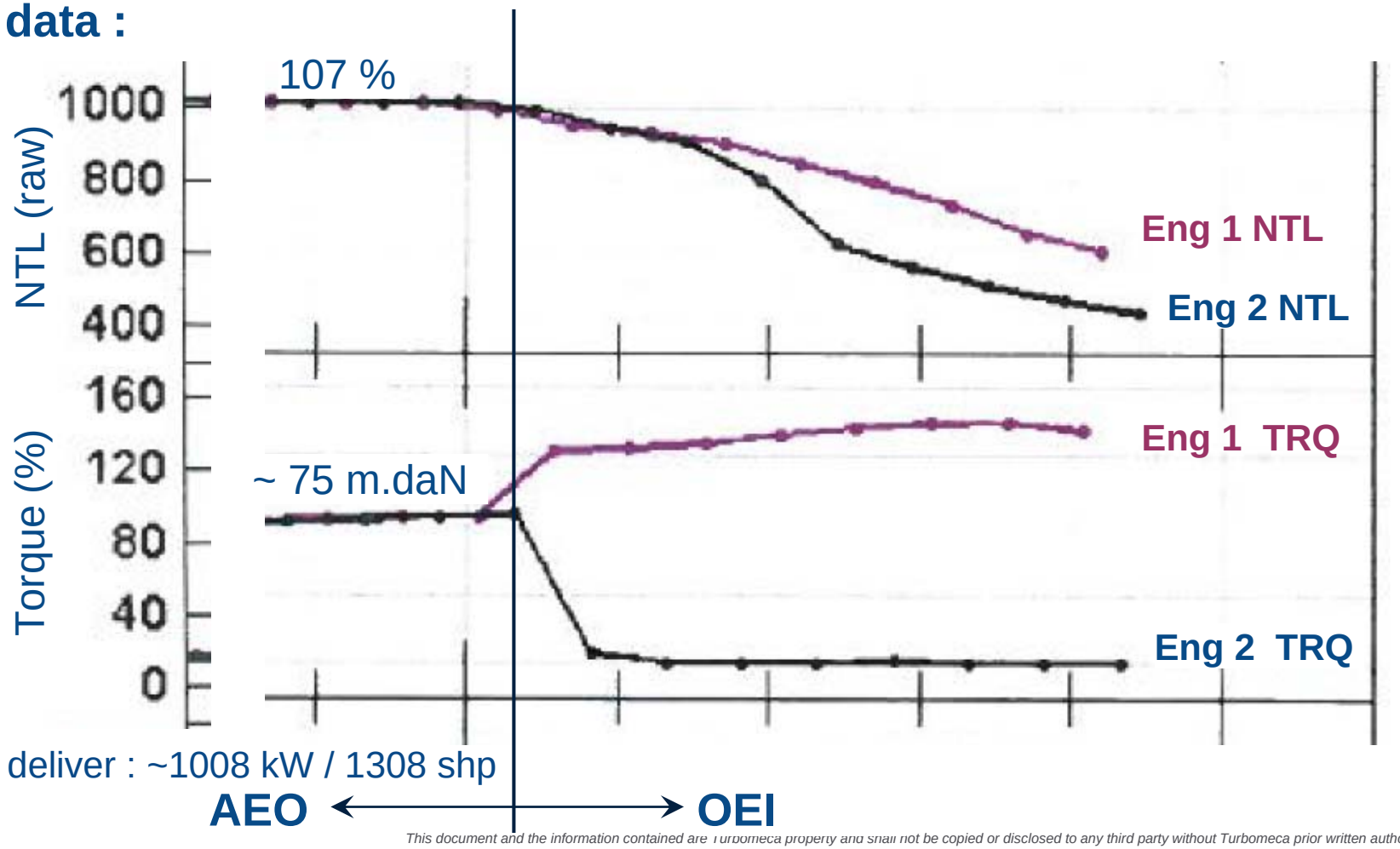
By X. Azéma
DVO/TEA
15th December 2011

SAFRAN
Turbomeca

F-HJCS Accident – Engine s/n 42266 performance level

Factory investigation on 14th to 16th December 2011

- **FDR data :**



Both engines deliver : ~1008 kW / 1308 shp

AEO ⟷ **OEI**

F-HJCS Accident – Engine s/n 42266 performance level

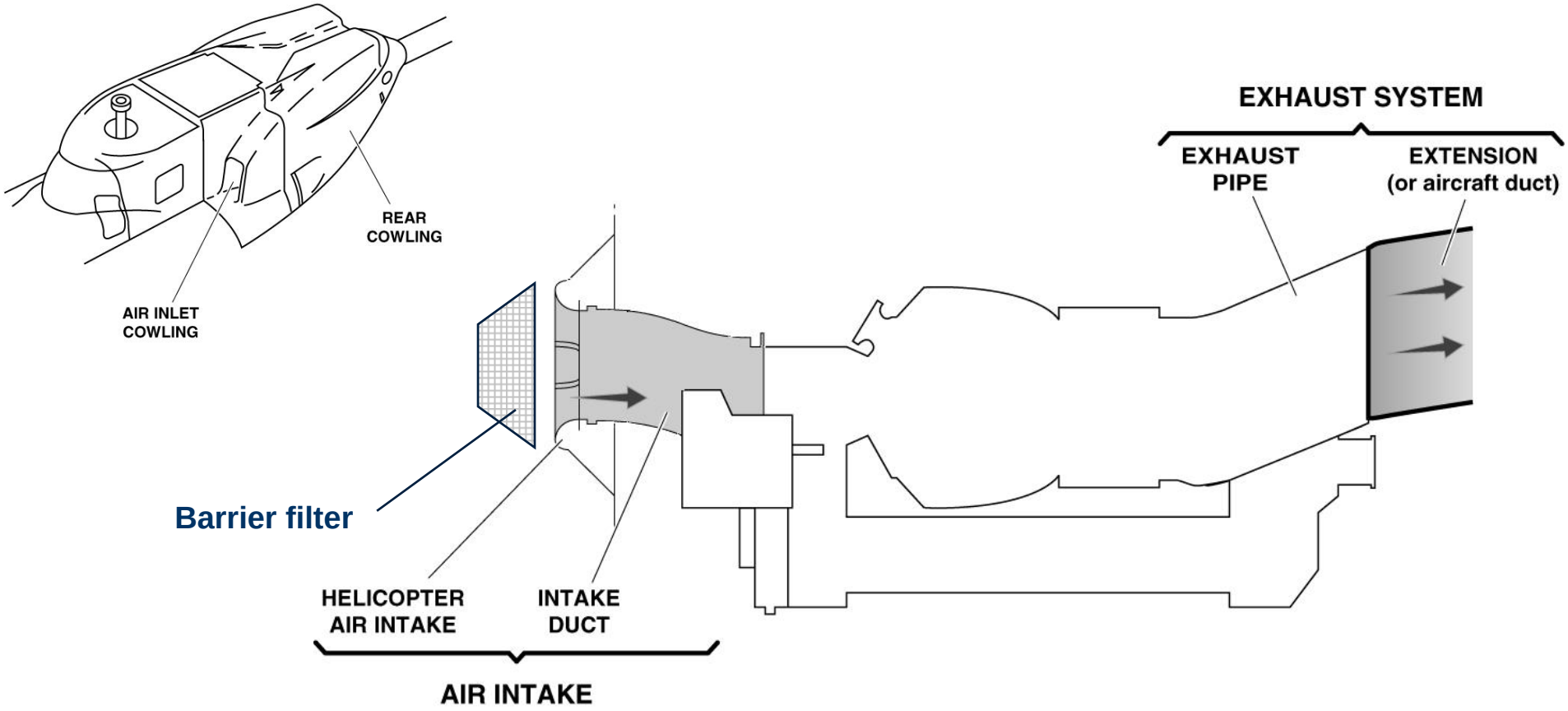
Factory investigation on 14th to 16th December 2011

- **Engine ratings definitions :**

F-HJCS Accident – Engine s/n 42266 performance level

Factory investigation on 14th to 16th December 2011

- **Engine installation influence :**



F-HJCS Accident – Engine s/n 42266 performance level

Factory investigation on 14th to 16th December 2011

- **Engine performance calculations :**
  - ⇨ **Conditions for day of accident :**
    - T0 = 28°C
    - P0 = 1006 hPa
    - NTL = 107% (6409 rpm)
  - ⇨ **Assumptions :**
    - Calculations based on minimum guaranteed performance of aged Arriel 2S2 engine
    - Installation losses at hover = 7.5 %
    - Power margin = 3% (estimated from log book records)
  - ⇨ **Performance calculations at OEI 30 sec rating :**
    - Power (mini uninstalled) = 727 kW / 975 shp (TQ = 108 daNm = 125%)
    - Power (mini installed) = 672 kW / 902 shp (TQ = 100 daNm = 112%)
    - **Power (3% margin, installed) = 693 kW / 929 shp (TQ = 103 daNm = 116%)**

F-HJCS Accident – Engine s/n 42266 performance level

Factory investigation on 14th to 16th December 2011

- **Engine performance calculations** (continued) **:**
  - ⇨ **Performance calculations at OEI 2 min rating :**
    - Power (mini uninstalled) = 646 kW / 866 shp (TQ = 96 daNm = 108%)
    - Power (mini installed) = 598 kW / 801 shp (TQ = 89 daNm = 100%)
    - **Power (3% margin, installed) = 615 kW / 825 shp (TQ = 91 daNm = 102%)**
  - ⇨ **Performance calculations at OEI Continuous rating :**
    - Power (mini uninstalled) = 608 kW / 815 shp (TQ = 91 daNm = 102%)
    - Power (mini installed) = 562 kW / 754 shp (TQ = 84 daNm = 94%)
    - **Power (3% margin, installed) = 579 kW / 776 shp (TQ = 87 daNm = 97%)**

YETAGUN A & B EMERGENCY RESPONSE PLAN

PC MYANMAR (HONG KONG) LIMITED

AMENDMENT SUMMARY

This sheet must be completed in detail at each revision once this document has been approved.

Details must include revision number, description and indication of which pages and paragraphs have been revised, date of revision approval, approvers' title and signature.

Rev	Description	Date	Approver Title	Signature
0	Original Issue	August 2000	HSE	
1	Changed to PCML format	June 2005	PM	
2	Updated & added Terrorist Threat Emergency Response,	April 2009	PM	

Notes: (1) Document Holders to update Amendment Record as and when amendments/new revisions are received.

(2) For description of amendment the Document Holder should indicate correction, modification, update and/or deletion issue.

(3) Document Holder to enter their company reference number, sign and date the record of entry.

(4) Where parts amendments are issued, the relevant page(s) will be identified with a lower case letter in the revision status line in the header.

Yetagun A & B Emergency Response Plan 095/003/003
Rev. 2, April 2009

REVISION REQUEST

AREAS OF CONCERN:

PAGE NO: SECTION:

PROPOSED ADDITION/AMENDMENT:

ORIGINATOR: INDICATOR: SIGNATURE:

PHONE NO: FAX NO:

PLEASE MAIL OR FAX TO OIM (OIM)

ORIGINAL DATE OF APPROVAL:

Myanmar (Hong Kong) Limited 4 of 69

Page 5

CONTENTS

Page 6

Appendix D:
Bomb Threat
Report Form

Abbreviations

CCR	Central Control Room
COSHH	Control of Substances Hazardous to Health
CRO	Control Room Operator
DCT	Damage Control Team
DCTL	Damage Control Team Leader
ECC	Emergency Co-ordination Centre
ERT	Emergency Response Team
ETA/D	Estimated time of Arrival / Departure
DM	Duty Manager
FSO	Floating, Storage, Offloading Vessel
FRC	Fast Rescue Craft
HLO	Helicopter Landing Officer
HSE	Health, Safety and Environment
IC	Incident Co-ordinator
LVR	LV Control Room
LQ	Living Quarters
MAC	Manual Alarm Call Point
MEDEVAC	Medical Evacuation from Site
NOK	Next of Kin
OIM	Offshore Installation Manager
OIC	Officer in Charge
OSC	On-Scene Commander
PCML	PC Myanmar (Hong Kong) Limited
POB	Personnel

POB	Personnel
SES	Southeast Shipping Board
TEMPSC	Totally Enclosed Motor Propelled Survival Craft
TR	Temporary Refuge
MC	Muster Checker
AMC	Assistant Muster Checker
GPA	General Purpose Alarm
LEL	Lower Explosive Limit

PREFACE

This Emergency Response Plan has been developed to ensure that PCML reacts quickly and effectively in the event of an emergency in the Yetagun field. The document is formulated to meet all Company and legislative requirement and to satisfy all moral obligations in the event of any such emergency.

This document shall be revised from time to time as required to ensure that any changes in the emergency response organisation are correctly documented and that any deficiency highlighted in emergency situations or emergency exercise are correctly addressed. Any proposed changes are to be submitted to the Operations Department, PCML Yangon Office as per the revision procedure contained in this document.

SECTION 1

INTRODUCTION

1.1 INTRODUCTION

All permanent personnel involved with emergency response on the Yetagun Platform are required to read and understand this contingency plan. Refer any questions or queries regarding emergency response on the Yetagun platform to your immediate Supervisor.

All visitors and short term contractors will be informed of their emergency response actions and responsibilities during their platform induction that will take place on arrival.

1.1.1 Yetagun Platform

Location Co-ordinates of the Yetagun Platforms:

Co- ordinates of the Well Head Platform
Latitude : 13 deg 02' 75.465" N
Longitude : 96 deg 52' 07.774" E

Co-ordinates of the Production Platform
Latitude : 13 deg 02' 55.0507" N
Longitude : 96 deg 52' 05.3088" E

1.1.2 Floating Storage Offloading Vessel(FSO)

Location Co-ordinates of FSO:

Co-ordinates of the FSO
Latitude : 13 deg 03' 43.440" N
Longitude : 96 deg 51' 05.520" E

1.1.3 Helicopter refuelling Facilities:

The Yetagun platform helideck is equipped with a helicopter refuelling skid. Storage capacity is 5000 Litres.

The FSO does not have a helicopter refuelling facility onboard.

1.2 OBJECTIVE OF THE MANUAL

The objectives of this manual is to provide a framework of organisational responsibility and lines of communications for response in the event of an emergency affecting assets of PC Myanmar (Hong Kong) Limited (PCML), or a vessel or aircraft on charter to PCML. This document describes the actions that are taken to mitigate, control, or evacuate from emergency situations and identifies responsibilities, procedures and equipment available to provide an effective response. The main sections address:

- Emergency team structure / training
- A description of the emergency organisation and the responsibilities of key offshore personnel.
- Basic guidelines, including description of Platform Alarms
- Emergency procedures in specific emergencies and evacuation of the Yetagun offshore facilities.

This Emergency Response Plan is designed to:

- Create an organisational frame work that will guarantee a rapid and effective response to an emergency situation,
- Assign in advance, the persons who will be responsible for taking actions,
- Determine, in advance, where the persons should go,
- Provide communication channels essential to task co-ordination,
- Provide a list of actions which must be taken and information which must be checked,
- Provide relevant information applying to different emergency situations.

The onshore response for the PCML is detailed within the 095/020/005 - Yangon Office Emergency Co-ordination Plan (Rev.2).

1.3 EMERGENCY RESPONSE PHILOSOPHY

Emergency response and hazard mitigation is a major consideration in the design of the Yetagun Platform. Every effort has been made to identify all potential, significant hazards on the installation and measures have been taken to reduce the risk of them occurring to as low as reasonably practicable. Any subsequent modifications from the original design have been subjected to rigorous HAZOP / HAZID studies. Not withstanding all of these measures, full attention to emergency response has been given and measures taken to ensure that in the unlikely event of an incident, the preservation of life is of the highest priority.

1.3.1 Purpose

The purpose of the emergency response system is to:

- Protect personnel after an emergency by providing means of escape to a place of "Temporary Refuge", from where a suitable response can be made to the incident.

- Provide means whereby control of the incident can be achieved or in the event that this is not possible, provide means of evacuation or escape from the platform.

1.4 PERSONNEL RESPONSIBILITIES

1.4.1 HSE Manager

The PCML Health Safety and Environmental Manager has the prime responsibility for ensuring onshore Emergency Response Team (onshore ERT) and Emergency Co-ordination Centre (ECC) is maintained in an operational state of readiness at all times and available to support any emergency situation.

1.4.2 Offshore Installation Manager(OIM)

The OIM is the most Senior Manager of the Yetagun field. He is appointed by the PCML Management and is responsible for the Health, Safety and Welfare of everyone onboard the Installation. All personnel on board must be notified of his identity. It is the responsibility of the OIM to ensure that all personnel have received suitable and adequate emergency response training.

1.4.3 FSO Unit Superintendent

The Unit Superintendent is the most senior person in charge of the Yetagun Floating Storage and Offloading vessel (FSO). He is appointed by the owners of the vessel, South Eastern Shipping (SES) and is responsible for the Health, Safety and Welfare of everyone onboard. The Unit Superintendent and the crew of the FSO operationally report to the OIM but functionally to the SES Base Manager who resides in the PCML Yangon office.

1.4.4 All Personnel

PCML encourages all employees and contractors to take an active part in the promotion of safety and requires all safety equipment to be inspected regularly to ensure that it is kept in a satisfactory condition. Furthermore, PCML will support the development and improvement of such equipment, in collaboration with other institutions, to promote higher standards of safety within PCML.

Note: Everyone working onboard the Yetagun Platform and Floating Storage facilities has a responsibility for their own safety and for the safety of others.

1.5 REFERENCES

The following controlled manuals provide additional guidance on emergency response for PCML operated Installation, etc: 095/020/002 - PCML Initial Incident Notification

Guideline (Revision 0)
095/020/005 - Yangon Office
095/020/006 - Medical Evacuation and Reception Procedures (Revision 0)
Emergency Co-Ordination Plan
14.07.10.209 - SBM Emergency Response Manual for FSO (Revision 0)
(Revision 2)
Oil Spill Contingency Plan

1.6 EMERGENCY DRILLS

Emergency drills shall be carried out weekly to ensure the Yetagun Platform and FSO personnel respond correctly and quickly to emergency alarms. Emergency drills must be carried out at weekly to clarify individual and group responsibilities for specific emergency situations.

Practice of the emergency response procedures helps ensure that personnel are ready to respond to emergency situations. Appropriate changes shall be made to the procedures in this plan to ensure they remain up to date.

1.7 RESPONSE TO EMERGENCIES

The Yetagun Platform Emergency Response Plan gives a descriptive overview of all platform personnel who have an active role to play in the response to any of the identified emergencies. Response charts for each of these personnel are provided to detail the actions necessary to each of the following emergencies:

- High level gas/fire/explosion,
- Condensate /diesel spill,
- Riser leak,
- Vessel emergencies,
- Helicopter emergencies,
- Serious illness/injury/fatality,
- Man overboard,
- Radioactive material incident,
- Bomb threat,
- Tropical storms.
- Terrorist threat

1.8 SHUTDOWN AND MAKE SAFE PROCEDURES

In all cases, on hearing the General Platform Alarm, personnel should stop work, make their work area safe and prepare to report to the muster area or to their lifeboat. Once the situation has been assessed and the muster is verified correct, the OIM may decide to restart certain equipment, which is needed to deal with the emergency, e.g. cranes, cutting equipment, etc. This will be co-ordinated through the Incident Co-ordinator.

Different equipment requires widely varying times to shut down operations and to make the workplace safe, depending on the task in hand. Trained personnel must still exercise their judgement as to the quickest and safest method to make safe for particular circumstances, prior to reporting to muster.

SECTION

095/020/005 - PCML Emergency Management Plan
Rev. 2, October 2007

SKO

PCML
EMERGENCY MANAGEMENT PLAN

PC MYANMAR (HONG KONG) LIMITED

TABLE OF CONTENTS

FOREWORD

Authority for Rev. 2 Issue

Issue Approval

Issue of this document has been formally approved by:

Signature:	
Name:	Mohd Zaini Mohd Yunus
Position:	General Manager PC Myanmar (Hong Kong) Limited
Date:	

Document Custodian

The following person has been assigned as the document custodian:

Signature:	
Name:	Edward Zan
Position:	Health, Safety & Environment Manager PC Myanmar (Hong Kong) Limited
Date:	

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14	PCML EMC Room	PCML - Myanmar
15	Offshore Installation Manager (OIM) Yetagun Platform	PCML - Myanmar
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22	PCSB Head South East Asia	PCSB - Kuala Lumpur
23	PCSB	PCSB

23	PCSB Corporate HSE	PCSB - Kuala Lumpur
24	PCSB EMC Room	PCSB - Kuala Lumpur
25	PETRONAS COMCEN	PETRONAS - Kuala Lumpur

PCML EMERGENCY MANAGEMENT PLAN 095/020/005
Rev. 2, October 2007

AMENDMENT SUMMARY

This sheet must be completed in detail at each revision once this document has been approved. Details must include revision number, description and indication of which pages and paragraphs have been revised, date of revision approval, approvers' title and signature.

Rev	Description	Date	Approver Title	Signature
0	Original issue	June 2004	GM	
1	Conversion to Incident Command System • Changed the title of the document from Yangon Office Emergency Coordination Plan to PCML Emergency Management Plan	January 2006	GM	
2	• Added Mercury Incident Emergency Response Plan • Updated PCML Emergency Contact Numbers	October 2007	GM	

Notes:
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(3) Document Holder to enter their company reference number, sign and date the record of entry.
4) Where part amendments are issued, the relevant page(s) will be identified with a lower case letter in the revision status line in the header.

PREFACE

This Emergency Management Plan has been developed to ensure that PCML reacts quickly and effectively in the event of an emergency in its operations. The document is formulated to meet all Company and legislative requirement and to satisfy all moral obligations in the event of any such emergency.

This document addresses the actions to be taken before, during, and after an emergency or disaster. The ability to contain and respond effectively to an emergency is one of the most challenging priorities facing our operations. The Company regards all hazards and risks can be managed and mitigate, if appropriate efforts were made. In doing so, PCML vigorously pursues efforts to deter and preempt these risks and manage through good HSE practice

This plan was built upon previous experiences for managing risks and further elaborated as emergency management strategies, a mechanism and management structure undertaken by the country office to mitigate all possible emergency situations. The management strategies include implementing measures to reduce our vulnerabilities, responding rapidly and effectively to incidents or actual emergency, and giving the highest priority to developing sufficient capabilities to mitigate and manage the consequences.

To ensure this management strategy is implemented in a coordinated manner, this Emergency Management Plan, hereafter referred to as the EMP, is designed to provide overall guidance to the Emergency Management Team concerning how they would respond to an incident or emergency that occurs in the Company jurisdictional areas. This plan outlines an organized and unified capability for a timely, coordinated response by the Emergency Response Teams and the assistance that will be rendered by other emergency support agencies and government authorities.

It establishes conceptual guidance for assessing and responding, notifying appropriate service providers and government agencies, and deploying the requisite resources to assist the emergency management team in facilitating inter-agency coordination for mitigation and controls. Lastly, it defines the relationships between structures under which the Company will marshal consequence management resources (including supports from Corporate Office) to respond to an emergency or crisis situation.

This document shall be revised from time to time as required to ensure that any changes in the emergency response organisation are correctly documented and that any deficiency highlighted in emergency situations or emergency exercise are correctly addressed. Any proposed changes are to be submitted to the HSE Department, PCML Yangon Office as per the revision procedure contained in this document.

ABBREVIATIONS AND ACRONYMS

The abbreviations and acronyms used in this document shall have the following meaning:

BA	Breathing Apparatus
CASEVAC	Casualty Evacuation
CEMS	Common Emergency Management System
CMT	Crisis Management Team
DCT	Damage Control Team
EMC	Emergency Management Centre
EMT	Emergency Management Team
ERT	Emergency Response Team
FSO	Floating Storage & Offloading
IC	Incident Commander
ICS	Incident Command System
KLCC	Kuala Lumpur City Centre
MEDEVAC	Medical Evacuation
MOGE	Myanmar Oil & Gas Enterprise
MS	Metering Station
NOK	Next of Kin
OIM	Offshore Installation Manager
OPU	Operating Unit
PCSB	PETRONAS Carigali Sdn Bhd
PCML	PC Myanmar (Hong Kong) Limited
PETRONAS COMCEN	Communications Centre at PETRONAS Head Quarters, Kuala Lumpur
PETTs	PETRONAS Twin Towers

PIC	Person-in-Charge
POC	Pipeline Operating Centre

GLOSSARY

Activation	The implementation of emergency response capabilities, procedures, activities, and plans in response to an emergency or emergency declaration.
Alert	Notification that a potential emergency situation exists or has occurred; direction for recipient to standby for possible activation of emergency response plan.
Area Command	An organization established to: 1) oversee the management of multiple incidents that are each being handled by an Incident Command System organization; or 2) to oversee the management of a very large incident that has multiple Incident Management Teams assigned to it. Area Command has the responsibility to set overall strategy and priorities, allocate critical resources based on priorities, ensure that incidents are properly managed, and ensure that objectives are met and strategies followed.
Assignments	Tasks given to resources to perform within a given operational period, based upon tactical objectives in the Incident Action Plan.
CASEVAC	Casualty Evacuation. The urgent evacuation of a sick or injured person because there is a risk of serious injury or death if more comprehensive medical treatment is not available quickly. A Casevac may involve special transport arrangements (ie. ad-hoc charters, air ambulance, etc.) and will almost certainly require medical staff to accompany the patient.
Cold Zone	This area contains the command post and such other support functions as are deemed necessary to control the incident. This is also referred to as the clean zone or support zone.
Common Emergency Management System (CEMS)	Combination of facilities, equipment, personnel, procedures, and communications operating within a common organizational structure with responsibility for management of assigned resources to effectively direct and control the response to an incident; PETRONAS ICS.
Control Zone	The designation of areas at an incident based upon safety and the degree of hazard. Many terms are used to describe the zones involved in a hazardous materials incident.

Emergency	Unexpected condition resulting in fire, explosion, oil and/or chemical spill, gas escape, serious injury or fatality, structure damage, total evacuation, severe electrical storm, aircraft or vehicle crash, vessel collision or sinking, deliberate act of arson or sabotage etc., all of which require prompt action.

Emergency Management Centre (EMC)	A site from which management-appointed response personnel exercise direction and control in an emergency.
Emergency Response Team	A team of personnel, trained to manage and respond to an emergency. These are the Site Emergency Response Team, Regional Emergency Response Team and Corporate Emergency Response Team.
Hot Zone	The area immediately surrounding an incident, which extends far enough to prevent adverse effects from hazardous materials releases to personnel outside the zone. This zone is also referred to as the exclusion zone or restricted zone.
Incident Commander	He is normally the first person to be contacted in case of emergency. He is responsible, in conjunction with the Person-In-Charge of the installation on which the emergency occurred, for assessing the scale of the emergency and initiating the appropriate response actions, including, if deemed necessary, calling out the Regional Emergency Response Team. He shall also notify all relevant parties of the emergency. During the emergency, the Regional Incident commander shall normally remain in overall charge of and is responsible for directing the Regional Emergency Response Team, for authorising, or obtaining authorisation for, any funds required for materials, equipment, contract services or specialist personnel necessary to resolve the emergency.
Incident Action Plan (IAP)	The IAP, which is initially prepared at the first meeting, contains general control objectives reflecting the overall incident strategy and specific action plans for the next operational period. When complete, the IAP will have a number of attachments.
Incident Command System (ICS)	An organized system of roles, responsibilities, and standard operating procedures used to manage and direct emergency operations.
Incident Objectives	Statements of guidance and direction necessary for the selection of appropriate strategies, and the tactical direction of resources. Incident objectives are based on realistic expectations of what can be accomplished when all allocated resources have been effectively deployed. Incident

objectives
alternatives.
must
be
enough
to
achievable
allow
and
for
measurable,
strategic
and
tactical

Jurisdiction	The range or sphere of authority. The teams and agencies have jurisdiction at an incident related to their legal responsibilities and authority for incident mitigation. Jurisdictional authority at an incident can be political/geographical (e.g., site, facility, state or federal boundary lines), or functional (e.g., police department, home ministry, etc.). (See Multi-Jurisdiction Incident.)
International Direct Dialing (IDD)	With an IDD telephone line, you can make a direct overseas call by using the international access code. With non-IDD telephones, overseas calls must be made via a Myanmar Telecomm Authority operator.
Installation	Offshore - Yetagun A & B Platforms, FSO, Drilling Rig, Vessels etc. Onshore - POC, MS, Dawei Base, Takheta Base and Yangon Office
Major Emergency	An emergency that, on assessment by the PIC, cannot immediately be brought under control with the first line response team and available equipment onsite without outside assistance.
MEDEVAC	Medical Evacuation. The routine evacuation of a sick or injured person to a location where they can receive more appropriate medical treatment than is possible at the work site. A MEDEVAC will typically involve normal transport arrangements, although timetables may be accelerated and medical staff may accompany the patient during travel.
Minor Emergency	An emergency which when assessed by the PIC, can immediately be brought under control with the first-line response team and available equipment located onsite without any outside assistance. However, if there is any uncertainty regarding the scale of the emergency, it should initially be treated as a major emergency.
Mitigate	Any action to contain, reduces, or eliminate the harmful effects of a spill or release of a hazardous substance/material.
Person-In-Charge (PIC)	PIC of the site/installation/drilling rig or vessel at the time of the emergency. He is the person who coordinates all emergency response activities carried out by his own personnel and any additional assistance from outside the installation.

Personnel On Board (POB)	POB is used in this document to mean the number of people at a certain location, not necessarily on a vessel or aircraft. For example "POB at the Pipeline Operating Centre" means the total number of people located at the POC near Kanbauk.

Personal Protective Equipment	The equipment provided to shield or equipment to isolate a person from the chemical, physical, and thermal hazards that may be encountered at a hazardous materials incident. Adequate personal protective equipment should protect the respiratory system, skin, eyes, face, hands, feet, head, body, and hearing. Personal protective equipment includes both personal protective clothing and respiratory protection.
Resources	All personnel and major items of equipment available, or potentially available, for assignment to incident tasks on which status is maintained.
Span of Control	A Command and Control term that means how many organizational elements may be directly managed by one person. Span of Control may vary from three to seven, and a ratio of one-to-five reporting elements is recommended.
Staging Area	That location where incident personnel and equipment are assigned awaiting tactical assignment.
Stakeholders	Any person, group, or organization affected by and having a vested interest in the incident and/or the response operation.
Strategy	The general plan or direction selected to accomplish incident objectives.
Tactics	Deploying and directing resources during an incident to accomplish the objectives designated by strategy.
Tactical Direction	Directions given by the IC that includes: the tactics appropriate for the selected strategy, the selection and assignment of resources, tactics implementation, and performance monitoring for each operational period.
Task Force	A group of resources with common communications and a leader assembled for a specific mission.
Triage	The classification of casualties according to the severity of their injuries in order to set priorities for treatment in a multiple casualty situation.
Unified Command (UC)	A unified team, that manages an incident by establishing a common set of incident objectives and strategies. This is

accomplished
without organizational authority, responsibility or accountability.
loss
Warm Zone The area where personnel and equipment decontamination
or and hot zone support takes place. It includes control
abdication points for the access corridor and thus assists in reducing
of the spread of contamination. This is also referred to as the
agency decontamination, contamination reduction, or limited
or access zone/corridor.

REFERENCED DOCUMENTS

095/020/002	PCML Initial Incident Notification Guideline
095/020/006	Medical Evacuation and Reception Procedures
095/020/007	Media Response Procedure
095/020/010	Guide on Return of Remains of Deceased
WW ALL S 07 001	PCSB Health, Safety and Environment Management System Manual
MY ALL S 07 003	PCSB HSEM 2.1 - Supervisory Safety Procedure Manual Section 4: Incident Investigation & Reporting
095/009/001/032	Safe Handling of Mercury and Mercury Compound

Section 1

INTRODUCTION

Contents

PC Myanmar (Hong Kong) Limited

1 INTRODUCTION

This Emergency Management Plan has been developed to provide guidelines to the on-duty emergency management team, who are directly or indirectly involved, when responding to emergencies occurring at PCML operational areas.

The document has been developed to complement the existing Site Emergency Response Plan, which cover in detail the required response to specific emergencies. The document provides details of the management philosophy utilised by PCML when defining the organisation and resources used in the response to an emergency and details the overall responsibilities required to handle effectively any emergency, which may arise.

All personnel with emergency roles and responsibilities must ensure that they become familiar with the requirements and procedures contained in this manual.

1.1 Purpose

This Plan establishes procedures to manage and coordinate the mitigation and control measures following an emergency or disaster situation. The following objectives have been established for this plan:

- Sets forth fundamental policies, planning assumptions, a concept of operations, the emergency management team responsibilities, and response and mitigation actions.
- Addresses linkages to other existing emergency management plan developed for specific incidents.
- Maximize the effectiveness of counter-measures through an established plan that consists of the following phases:
  - Notification and mobilization phase to activate the plan
  - Mitigation phase to minimize impact and damages
  - Protect employees, contractors, and the public from injury
  - Minimize damage or injury to people, property, and the environment
  - Mitigate the effect of an incident on the commercial and business life of PCML.
- Assign responsibilities to designated EMT members and provide guidance for emergency support groups during prolonged periods of mitigation.
- Serves as the foundation for the development of detailed supplemental procedures to complement this plan for response activities, rapidly and efficiently.
- Ensure compliance with applicable regulatory requirements and industry standards for emergency management.

The plan is organized in sections for easy reference. Each major section deals with a component of the plan beginning with governing policies, plan activation through emergency counter-measures and restoration of normal operations. The appendices contain information such as forms which may be required during the emergency response process; partners

contact
lists,
vendor
lists,
etc.

1.2 Scope

All activities that are managed by PCML are covered by this Emergency Management Plan. All EMT members are required to understand and be familiar with their duties as they pertain to this Plan. When there is an actual emergency or potential for an emergency, the procedures written in this Plan will be carried out immediately.

This document covers the response of PCML to emergencies affecting Myanmar Operations, specifically the following area operations:

- Yetagun A & B Platforms
- Pipeline Operating Centre (POC)
- Metering Station (MS)
- Floating Storage and Offloading (FSO)
- Yangon Office
- Drilling Rig
- Vessels
- Etc.

Although detailed procedures are given for the onshore emergency response teams, general information is also provided on the total company response to the following emergency situations.

(a) Emergencies on platforms
(b) Emergencies on mobile drilling rigs
(c) Emergencies involving helicopters
(d) Emergencies involving supply vessels
(e) Emergencies at onshore operating facilities

This document should be used in conjunction with the following according to the nature of the emergency.

(a) Oil Spill Contingency Plan
(b) Mobile drilling rig emergency procedures (contractors)
(c) MEDEVAC / CASEVAC Procedures
(d) Accident Reporting Procedures
(e) Diving Emergency Procedures (Contractors)
(f) General Procedures for Simultaneous Operations.

This plan shall be used by the on-duty EMT members that are tasked to provide emergency assistance. This plan will be reviewed annually and updated when any of the following occurs:

- Applicable regulations are introduced or revised.
- The

The plan fails in an exercise or real emergency.

- Changes to the configuration of the facility.
- New hazards are introduced into or near the facility.
- Existing hazards are eliminated.
- There are changes to personnel who have a role in the plan.

All changes shall be approved by PCML-EMT. The complete Plan shall be distributed to all relevant parties.

1.3 Emergency Response Framework

During an emergency situation, the centre of operation is known as the Emergency Management Centre (EMC). All information and coordination, regarding emergency management operations, shall flow through the EMC. The centre is staffed by the Emergency Management Team (EMT) and shall include one Incident Commander and members of the appointed representatives.

Within this framework, the EMT can provide, equipment, supplies, facilities, managerial and technical services in support of site ERT mitigation and control efforts. The Incident Commander and the other team members shall be involved in providing all required supports.

Under PETRONAS Incident Command System, the HSE Department has been delegated with primary responsibility for coordinating PCML emergency preparedness, planning, management, and emergency assistance functions. The department also has been delegated with responsibility for establishing emergency assistance policy. In this stewardship role, the department has the lead in developing this plan.

1.4 Assumptions

This Plan applies and shall be used by the emergency management team to coordinate emergency management operations occurring at PCML operations. The plan presented here is based on the following planning assumptions:

(a) The plan is current, having been reviewed, maintained and updated on an annual basis. Plan training exercises have been performed.
(b) Emergency mitigation is performed in accordance with the procedures that have been set forth within this plan and appendices.
(c) The EMT has current strategies in place and any weaknesses have been identified and addressed.
(d) Appropriate emergency response equipment are available and accessible.
(e) The plan is to be a document that reflects a changing environment. Therefore, part of the plan is to implement on-going practices, in order to sustain the state of readi ness.

1.5 Plan Structure

This Plan utilizes the Common Emergency Management System (PETRONAS ICS) in organizing manpower and equipment during response and recovery operations.

The plan is organized in sections for easy reference. Each Section deals with a component of the Plan beginning with governing policies, plan activation through restoration of normal

ICS, the following classification applies:

Tier I Minor Emergency

A situation where there is no danger to life and where risk of damage to property and environment is minimal. The incident is within the control of the OPU.

Tier II Major Emergency

A situation where there is danger to life and risk of damage to property and environment. The incident is within the control of the OPU with limited external assistance.

Tier III Crisis

Where there is potential for multiple fatalities and severe damage to property and the environment involving neighboring sites and surrounding communities. The incident is clearly beyond the capacity of the OPU to control and consequently requires action from PETRONAS corporate, government or other external parties.

2.4.1 Types of Emergencies

There are two broad categories of emergency situation:

- Operational
- Socio-political

There are twenty one recognised operational sub-categories:

1. Bomb threat (telephone and/or mail)l
2. Man overboard
3. Gas Release
4. Fire and/or explosion
5. Well blowout
6. H_2S release
7. Spill/Pollution
8. Mercury poisoning and Uncontrollable spill
9. Pipeline/riser incident
10. Diving incident
11. Helicopter emergency
12. Errant vessel/aircraft
13. Vessel collision
14. Structural failure
15. Radioactive incident
16. Refugees/Pirates & Robber
17. Criminal acts
18. CASEVAC/MEDEVAC
19. Adverse weather
20. Emergency on export tanker
21. FSO mooring system failure

And five recognised Socio-political sub-categories:

1. Natural disaster
2. Civil unrest
3. Kidnap/extortion
4. Terrorism
5. War

It is important that the type of emergency is identified as early as possible, so that the appropriate emergency response action plans can be taken.

By their nature, emergency situations are usually

By their nature, emergency situations are usually unique and unpredictable. Nevertheless, "emergency response action plans" for each of the twenty-five emergency sub-categories listed above are as per **Section 7**. The actual emergency response actions to be taken will be determined by discussion and consultation within and between the emergency response teams at site and at the EMC.

2.5 Management of Efforts

The overall responsibility for the safety of the site rests with the PIC. He has the authority and responsibility to take the immediate response actions required to control any emergency; including directly mobilising or requesting the use of necessary resources such as aircraft, materials, etc., if required.

At Yangon office, the IC will be the overall in charge and responsible for directing key personnel, authorising or obtaining authorisation of any funds required for materials, equipment, contract services or specialist personnel necessary to bring the emergency under control. It is the IC responsibility to establish contact and advise the management at PCSB Head Office, brief them on the emergency and the actions being taken.

The IC shall respond to all requests for assistance from the PIC without delay. It is the sole responsibility of the PIC to identify such requirements, and of the IC and EMT to implement them. If outside assistance is required from other Agencies, such as for the use of equipment, all requests will be channelled through the IC. Requirements should subsequently be confirmed by fax or in writing. It will be the IC responsibility to ensure that all relevant authorities and organisations are informed and reports subsequently prepared and submitted.

2.6 Resource Coordination and Management

To the maximum extent possible, internal local resources at site shall be used as the first line of support for emergency recovery operations. Arrangements and working collaboration should be made with other agencies as an additional option for resource support after an emergency declaration.

Once PCML resources and capabilities are exhausted, PCSB Corporate assistance may be provided to support operational requirements and priorities. Utilization can be requested from the EMT.

Resources are acquired using the standard company procurement vehicle such as a purchase order, blanket purchase agreement, or contract. Additionally, the IC may authorise purchase under the emergency provision power directing completion of a specific tasks.

2.7 Emergency Preparedness

It is PCML policy to ensure the emergency preparedness of all their emergency organisations. Regular training of all personnel involved in Emergency Response activities shall take place to ensure that the highest standard of emergency response preparedness exists throughout PCML Operations. It is mandatory for those personnel selected for emergency duties to undertake the required courses in the Crisis Management and Emergency Response Training Programme in order for them to be effective in their role.

Three (3) levels of training have been identified:

Level 1
Level 2
Level 3

Level 1

Emergency response training for the Worksite ERT. The training is to be taken twice a year for each crew change or shift. The objective of the training is to provide an opportunity for the Worksite ERT as a whole to practice all elements of their response from the PIC in his appraisal of the situation, the deployment of resources and command and control aspects, to DCTs in intervention actions, fire fighting and casualty retrieval.

NB: This training is in addition to the routine musters and drills carried out at worksite and should follow approved scenarios.

Level 2

Emergency response training for the Yangon Office EMT. The training is to be taken twice a year. The objective of the training is to provide Yangon Office EMT members and Support Team members an opportunity to practice their respective roles in a simulated emergency situation.

Level 3

Emergency response training for all levels of the Emergency Response Organisations i.e Worksite ERT, Yangon Office EMT and Support Teams and PCSB HQ EMT and Support Teams. There will be one training a year. The objective of the training is to provide an opportunity for all levels of the PCML and PCSB emergency response organisations to work together to deal with a major emergency.

operations. The appendices contain information such as organisation chart, dedicated contact numbers, vendor lists, etc.

1.6 Plan Ownership and Maintenance

This plan shall be reviewed annually by the Custodian. All EMT members shall be responsible for reviewing their team responsibilities and making any recommendations for change. The plan will also be updated as a result of all post-incident review processes and as a result of information gained from plan training exercises.

Recommendations arising from the annual review will be submitted to PCML management for discussion and approval by December 1 of each year. Minor updates may be made by the Custodian at any time during the year. The Custodian holds ownership to this Manual.

The proper maintenance of this Plan will be the responsibility of ALL copy holders. It will be their responsibility to incorporate all approved revisions into their assigned copy to ensure that the plan is maintained. All removed pages are to be properly disposed or shredded.

SECTION 5 – HELICOPTER EMERGENCIES

1.0 HELICOPTER EMERGENCIES

1.1 DEALING WITH A MAJOR HELICOPTER FIRE

To effectively control a crash situation with associated fire, the H.L.O. must:

MAJOR HELICOPTER FIRE CHECKLIST		
Item	**Action**	√
1	Make the initial attack with the helideck foam monitors, and attempt to suppress the major flame mass on and around the critical area (the area within the helicopter that holds the passengers and crew).	
2	Make sure that with the foam monitors still applying foam onto the airframe and with the fires on the helideck out, the helideck crew can approach with handlines and douse any cabin fires in order to rescue the passengers from the wreckage.	
3	Ensure that access to the aircraft is via all exposed doors and windows; entry must be gained by using the emergency door release mechanisms.	
4	Ensure that if the engines are still running then the H.L.O. must direct foam/water into the engine intakes until the engine cuts out.	
5	Ensure that to prevent the spread, or re-ignition of fire, it is essential that the H.L.O. gains access to the helicopter and endeavours to close the fuel cocks and throttles, and isolates the battery master switch.	
6	Remember that all accidents will be different, however the emergency first aid team must, depending on circumstances: (1) deal with the unconscious passengers (2) then deal with the conscious injured passengers (3) then deal with the non injured passengers	
7	The response must be such that, in the event of a helicopter crash, the emergency support team and the emergency first aid team will close up on the helideck, so as to support the H.L.O. and the helideck crew fire team. * The emergency support team will await the instructions of the H.L.O.	
8	Remember that passengers and crew are likely to be contaminated with aviation fuel, if so they must be removed from the immediate vicinity, and stripped off as soon as possible.	
9	Ensure that when all fire fighting and rescue tasks have been carried out, the H.L.O. must endeavour to minimise the risk of re-ignition by directing his teams to: * Cover any fuel spillages with foam. * Set up "hose snakes" to arrest the spread of fuel and fuel contaminated water. * Search out and extinguish any fires within the airframe using CO_2. * Attempt to stop all fuel leaks from the helicopter. * Post firemen with dry powder extinguishers.	

1.2 HELICOPTER DITCHING

The helicopters servicing the FSO are provided and controlled by the Client, consequently the emergency procedures set in motion in the event of a helicopter ditching away from the FSO are an integral part of the Client's overall emergency procedures. However there is an interface with the FSO.

In the event of a helicopter ditching in the sea, the two scenarios described below would come into effect.

1.2.1 *Helicopter Ditching in Flight from or to the FSO, but not in the immediate Vicinity.*

The Client's emergency response is activated and controlled from their office in Yangon. Communication is established between the Client's *Emergency Control Centre* (ECC), the Yetagun platform and the FSO to facilitate possible deployment of FSO resources and to maintain information update to the FSO, who in turn interface with the SBMPC Operations office in KL.

1.2.2 *Helicopter Ditching in the Vicinity of the FSO*

Prior to the arrival or departure of a helicopter from the FSO, the following is to be in place, depending on the weather conditions prevailing at the time in the vicinity of the FSO.

Preferably, the field stand-by boat will be in close support around the FSO with the fast zodiac ready for immediate launch. If the stand-by boat cannot be in close support, i.e. because there is an offload taking place, and she is secured to the export tanker or she is deployed elsewhere in the field, then the fast zodiac should still be available for launch.

If the above is not possible, then the FSO starboard lifeboat should be ready for immediate launch.

Should the helicopter ditch, the ability to reach the crash site as quickly as possible is essential. Once at the crash site, assistance to those on board the helicopter will entail transferring them to the lifeboat as safely as possible without hazarding the rescuers.

Once personnel are recovered from the helicopter, they should be taken to a safe refuge as soon as possible, which may be the stand-by boat, the FSO or the Yetagun platform.

All personnel on the helicopter must be accounted for by reference to the flight manifest.

BEA f-cs110711_tec02
Date of issue 20/04/2012

Technical Document

Computer examination

Accident on **July 7th, 2011**
in **Yetagon (Myanmar)**
to the **Sikorsky S-76**
registered **F-HJCS**
operated by **Heli-Union**

BEA
Bureau d'Enquêtes et d'Analyses
pour la sécurité de l'aviation civile
Ministère de l'Écologie, du Développement durable, des Transports et du Logement

Foreword

This document completes the document referenced BEA f-cs110711_tec01 issued after examining the flight data recorder and both engine control units.

This document and the photographs and technical information contained herein are subject to the laws relating to communication and confidentiality embodied in European Regulation 996 of 20 October 2010.

The conclusions of this document are based on the work undertaken by the BEA (Bureau d'Enquêtes et d'Analyses pour la sécurité de l'aviation civile). They should not be used to prejudge the final conclusions of the safety investigation.

Contents

Glossary

CF	Compact Flash
eVXP	Enhanced Vibration eXPert
FDR	Flight Data Recorder
HUMS	Health and Usage Monitoring System
MIMs	Maintenance Instruction Manuals
PCMCIA	Personal Computer Memory Card International Association

1 – EQUIPMENTS EXAMINED

	Compact Flash card
	
Manufacturer	SiliconSystems
Part number	SSD-C01GI-3100

The helicopter was equipped with a Honeywell eVXP.
The eVXP is a HUMS system but is not a flight recorder. The recorded data are used for maintenance purposes. These data are stored in a memory card (CF), inserted in a PCMCIA adapter plugged in the eVXP computer.

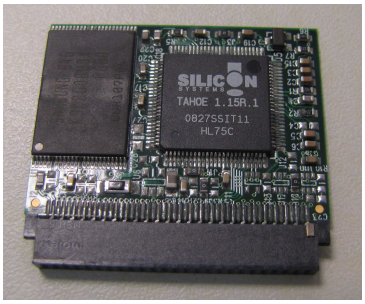
The PCMCIA adapter, containing the CF card, was brought to the BEA by the HéliUnion representative on January 4th 2012. This equipment has never been stored in a container filled with water after the helicopter recovery.

2 – WORK PERFORMED

Both PCMCIA adapter and CF card were in good condition.

The CF card was extracted from the PCMCIA adapter and presented traces of corrosion (see picture ref 1).

A preliminary X-Ray inspection revealed that the CF card contained a single memory component.



Picture ref 1

After opening, the board was cleaned and read out. The whole files were recovered. and have been sent to Honeywell for analysis and decoding purposes.

3 – RESULTS

All the data were recovered from the eVXP computer and successfully decoded. The engineer values are issued in the Honeywell report:

0000033416-760740 Data Review.pdf

Note: time is set by user through the display unit (laptop) and is not synchronized with GPS.

Findings:

Concerning the computer itself:

- self calibration tests were performed at 08 h 56 min 32 on July 11th, 2011 and passed;
- the eVXP system was operating properly, data collection stopped at 10 h 20 min 08 on July 11th, 2011. The flight data parameters were recorded in the memory and are provided in an Excel file:

  HFDM_760740_2011_07_10_09_31_51.xls

  The relevant parameters (for helicopter attitude and engines) were plotted, listed and compared to FDR parameters. Plots are appended to this document. Sensors, sample rates and filtering laws are different in the FDR and eVXP computers.

Concerning health function (HUMS):

- no maintenance test was recorded in the eVXP,
- tail rotor balance data were last collected at 09 h 01 min 05 on July 11th, and tail rotor 1/rev levels were within MIMs,
- main rotor balance data were last collected at 10 h 02 min 18 on July 11th, and main rotor 1/rev and 4/rev vibration levels were within MIMs,
- main rotor spectrum data were last collected at 10 h 12 min 59 on July 11th, and main rotor 1 thru 10/rev vibration levels were within MIMs,
- all other vibration levels were last collected at 10 h 12 min 44 on July 11th, and they were within MIMs. The generated file is provided in the pdf file:

  0000033416-760740 Condition Indicator Levels 7-11-11.pdf

  The Honeywell report indicates the average of each parameter computed during the timeframe (main rotor speed above 95%). This timeframe started at 09 h 02 and ended at 10 h 12 min 44.
- two exceedances were recorded at 10 h 19 min 59 on July 11th, 2011 on:
  - Engine #1 T45, over 893.0°C for 10.8 seconds and peak temperature measured at 956.00°C,
  - Engine #1 T45 (indicated), over 893.0°C for 10.5 seconds and peak temperature measured at 972.40°C.

Concerning usage function (HUMS):

- The last usage report was received at 11 h 03 min 35 on July 10th and is provided below:

USAGE REPORT for Model S76C++ ONBRD, A/C 760740

Log/Flight 1 Stored 07-10-2011 11:03:35

ID	Description	Value	Units
RTR-TIME	Turn Time	477.7	HRS
AC-TO	Take-offs	617.0	COUNT
AC-LAND	Landings	617.0	COUNT
RTR-STRT	Starts	465.0	COUNT
RTR-BRKA	Brk Appl	392.0	COUNT
RTR-BRKO	Brk Over	11.0	COUNT
E1-RTIME	Run Time	475.5	HRS
E1-C1N1L	N1 1 Cyc Lo	387.5	COUNT
E1-C1N1H	N1 1 Cyc Hi	1386.0	COUNT
E1-C2N1	N1 2 Cyc	1386.0	COUNT
E1-C3N1	N1 3 Cyc	1386.0	COUNT
E1-C4N1	N1 4 Cyc	1386.0	COUNT
E1-CN2L	N2 Cyc Lo	88.0	COUNT
E1-CN2H	N2 Cyc Hi	1088.0	COUNT
E1-OE30T	OEI (30s) Sec	0.0	SEC
E1-OE30C	OEI (30s)	0.0	COUNT
E1-OE2T	OEI (2m) Sec	0.0	SEC
E1-OE2C	OEI (2m)	0.0	COUNT
E1-HIPST	HIPSARM Min	0.0	MIN
E1-HIPSC	HIPSARM Cnt	0.0	COUNT
E1-FCNT	E1 Fault Cnt	54.0	COUNT
E2-RTIME	Run Time	476.1	HRS
E2-C1N1L	N1 1 Cyc Lo	390.8	COUNT
E2-C1N1H	N1 1 Cyc Hi	1390.0	COUNT
E2-C2N1	N1 2 Cyc	1390.0	COUNT
E2-C3N1	N1 3 Cyc	1390.0	COUNT
E2-C4N1	N1 4 Cyc	1390.0	COUNT
E2-CN2L	N2 Cyc Lo	85.3	COUNT
E2-CN2H	N2 Cyc Hi	1084.0	COUNT
E2-OE30T	OEI (30s) Sec	0.0	SEC
E2-OE30C	OEI (30s)	0.0	COUNT
E2-OE2T	OEI (2m) Sec	0.0	SEC
E2-OE2C	OEI (2m)	0.0	COUNT
E2-HIPST	HIPSARM Min	0.0	MIN
E2-HIPSC	HIPSARM Cnt	0.0	COUNT
E2-FCNT	E2 Fault Cnt	147.0	COUNT
AU-TIME	AU Time	559.4	HRS

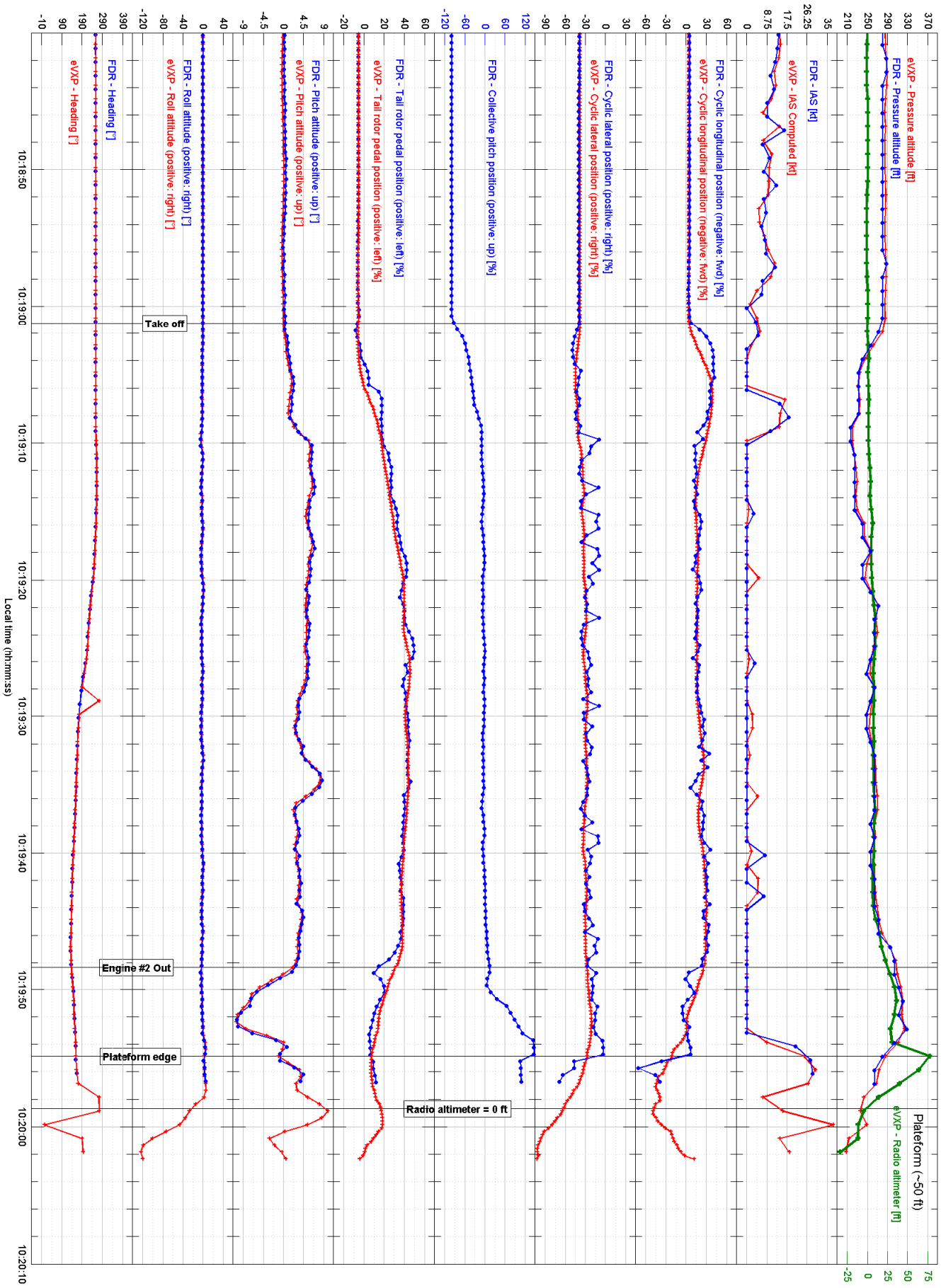
The CF card is securely kept at the BEA laboratory.

Appendices

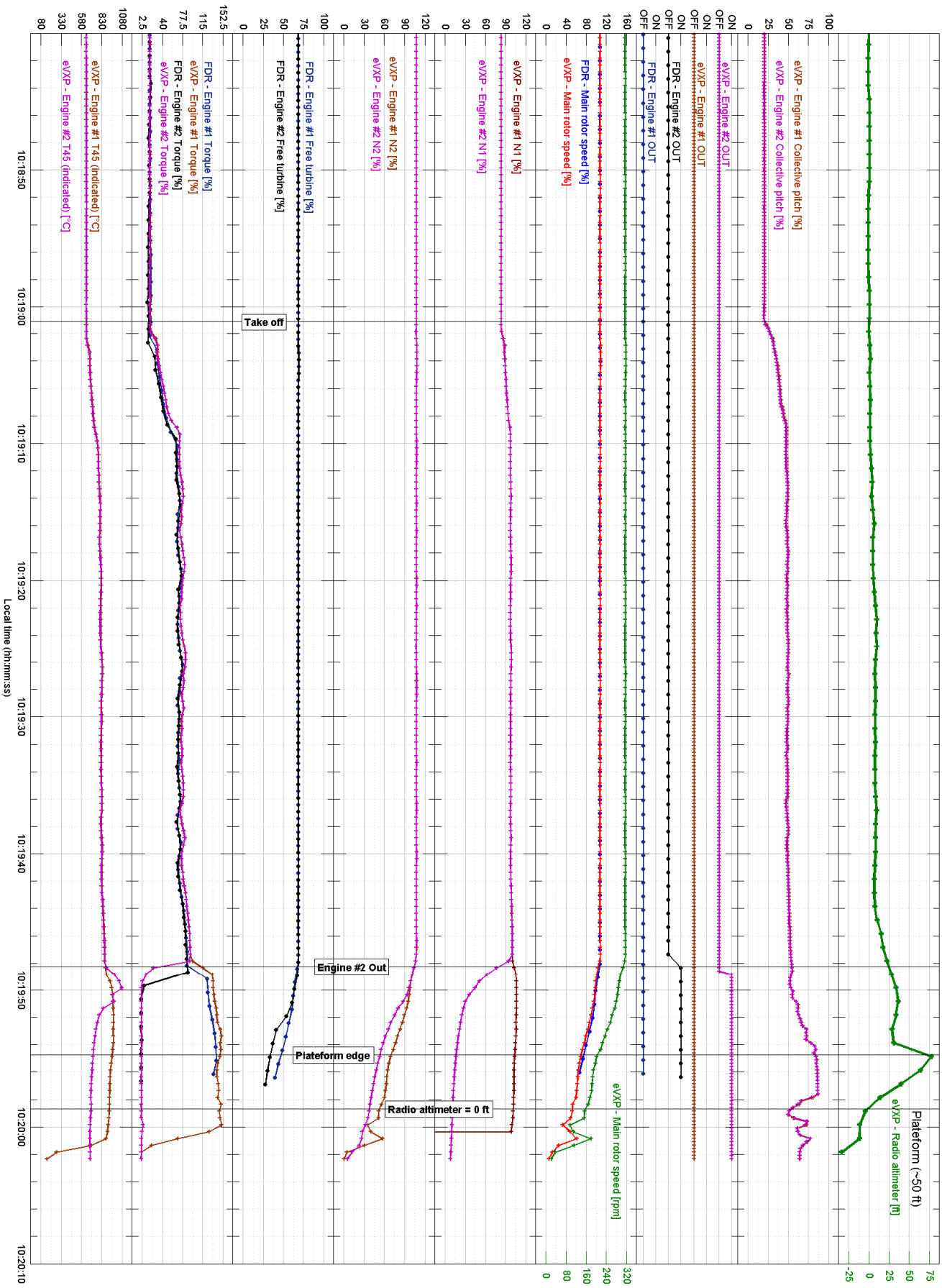
Appendix 1: Plot of attitude data

Appendix 2: Plot of engines data

APPENDIX 1: PLOT OF ATTITUDE DATA



APPENDIX 2: PLOT OF ENGINES DATA



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RÉPUBLIQUE FRANÇAISE

BEA f-cs110711_tec01
Date of issue 13/12/2011

Technical Document

Flight Recorder and Computers Examination

Accident on **July 7th, 2011**
in **Yetagon (Myanmar)**
to the **Sikorsky S-76**
registered **F-HJCS**
operated by **Heli-Union**

BEA
Bureau d'Enquêtes et d'Analyses
pour la sécurité de l'aviation civile
Ministère de l'Écologie, du Développement durable, des Transports et du Logement

Foreword

This document and the photographs and technical information contained herein are subject to the laws relating to communication and confidentiality embodied in European Regulation 996 of 20 October 2010.

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Contents

Glossary

ECU	Engine Control Unit
EEPROM	Electrically-Erasable Programmable Read-Only Memory
SSMVDR	Solid State Memory Voice/Data Recorder

1 – EQUIPMENTS EXAMINED

	SSMVDR	ECU #1	ECU #2
			
Manufacturer	Honeywell	Thales	Thales
Part number	980-6021-066	70BML01000	70BML01000
Serial number	ARCOMBI-12023	7028	8087

The aircraft was equipped with one Solid State Memory Voice/Data Recorder and two Electronic Control Units.
The SSMVDR is the mandatory flight recorder on board; the ECU controls the fuel regulation for the engine. The ECU is not a flight recorder; the recorded data is used for maintenance purposes.

The three computers were brought to the BEA by the French Accredited Representative on December 2nd 2011. They were stored in containers filled with water.

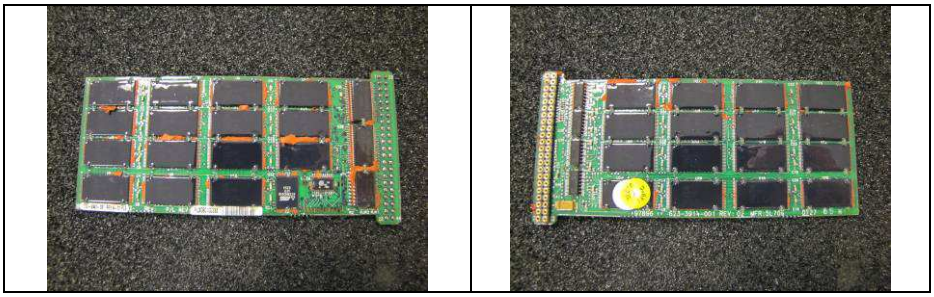
Opening operations were performed on December 2nd 2011; they were videotaped.

Read-out operations of the SSMVDR were performed on December 12th 2011.

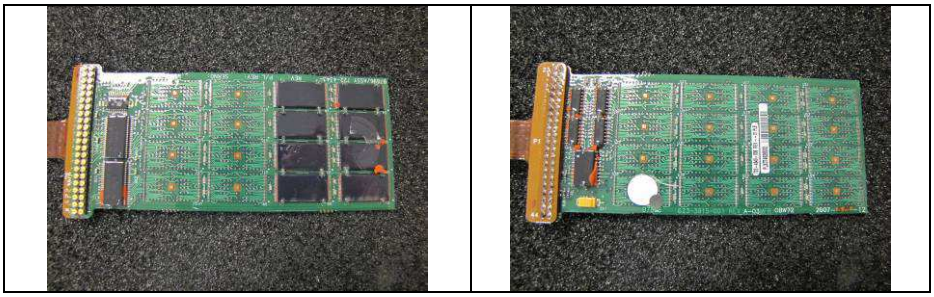
2 – WORK PERFORMED

2.1 SSMVDR

The computer is in good condition.
The opening and read-out operations were performed following BEA and Honeywell procedures.
The double memory board is in good condition and has been placed in an oven at 90℃ for 48 hours and then at 40℃ for drying.
Electrical checks were performed on the double boards outputs and resistive values were compared to reference tables provided by the manufacturer. The analysis of the few discrepancies observed concluded that the download could be attempted.



Board #1

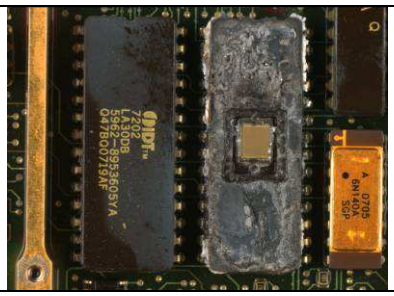
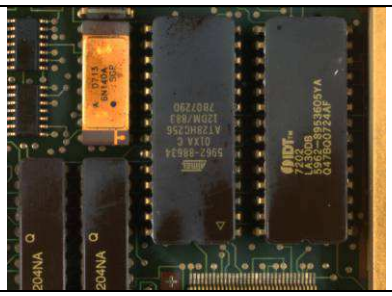


Board #2

The memory boards were connected with a BEA connector to the BEA 6025 chassis used as a playback system. The read out was performed using the manufacturer download equipment RPGSE. The file containing the cockpit voice data was downloaded successfully, but the file containing the flight data was partial.
The file containing the flight data was therefore downloaded using the BEA in-house memory reader connected to the memory board. The 9 chips containing the raw data were successfully read out. Each memory was read at least two times and the downloaded data was identical.
A binary file, in raw bitstream format, was rebuilt.

2.2 ECU #1

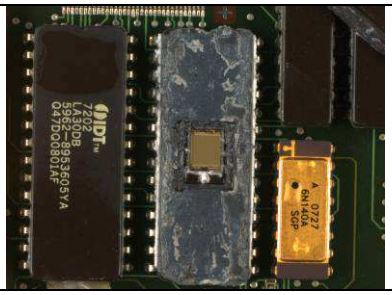
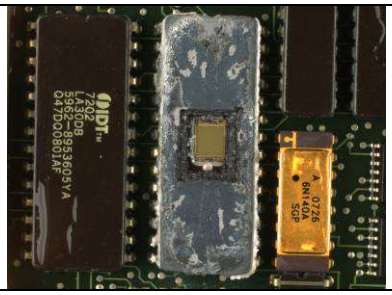
The computer is in good condition.
Both modules A and B were extracted from the computers. The main boards of each module are in good condition. The module A memory component in which the data is stored is not in good condition. The top cover of the ceramic package is not glued anymore; the bonding wires linking the lead frame pins to the silicium die are broken. The module B memory component seems to be in good condition. A small white deposit (probably glue) has been observed around the package.

	
Module A	Module B

The two main boards were placed in the oven at 90℃ for 48 hours and then at 40℃ for drying.

2.3 ECU #2

The computer is in good condition.
Both modules A and B were extracted from the computers. The main boards of each module are in good condition, except the memory components (EEPROM AT28HC256) in which the data is stored. The top covers of the ceramic package are not glued anymore; the bonding wires linking the lead frame pins to the silicium die are broken.

	
Module A	Module B

The two main boards were placed in the oven at 90℃ for 48 hours and then at 40℃ for drying.

3 – RESULTS

All the data was recovered from the flight data file by reading out the memory chips. The flight of the event is recorded. Preliminary data were plotted and listed.
Some parameters have not been validated yet, complementary information is required:

- Collective pitch position,
- Cyclic lateral/longitudinal positions,
- Tail rotor pedal position,
- Engine #1 and #2 free turbine.

For these parameters, the validated raw data was given.

The file containing the voice data was then decompressed with Playback tool software utility (998-3414-507) into the standard audio wave files.
The four audio files could be identified as follow:

- three files containing the last two hours of recording of captain (track 1), first officer (track 2), every one mixed with VHF communications, and a third channel usually called 'flight engineer-or public address' (no data on this channel for this helicopter - seems to be not connected as per design),
- one file containing the last two hours of recordings of the Cockpit Area Microphone (CAM).

Synchronization with the FDR was performed based on the local time (10 h 19 min) of the crash reported by Investigator In Charge; this allowing a preliminary transcription.

No data was retrieved from the two ECU yet.

The Investigator In Charge was provided with:

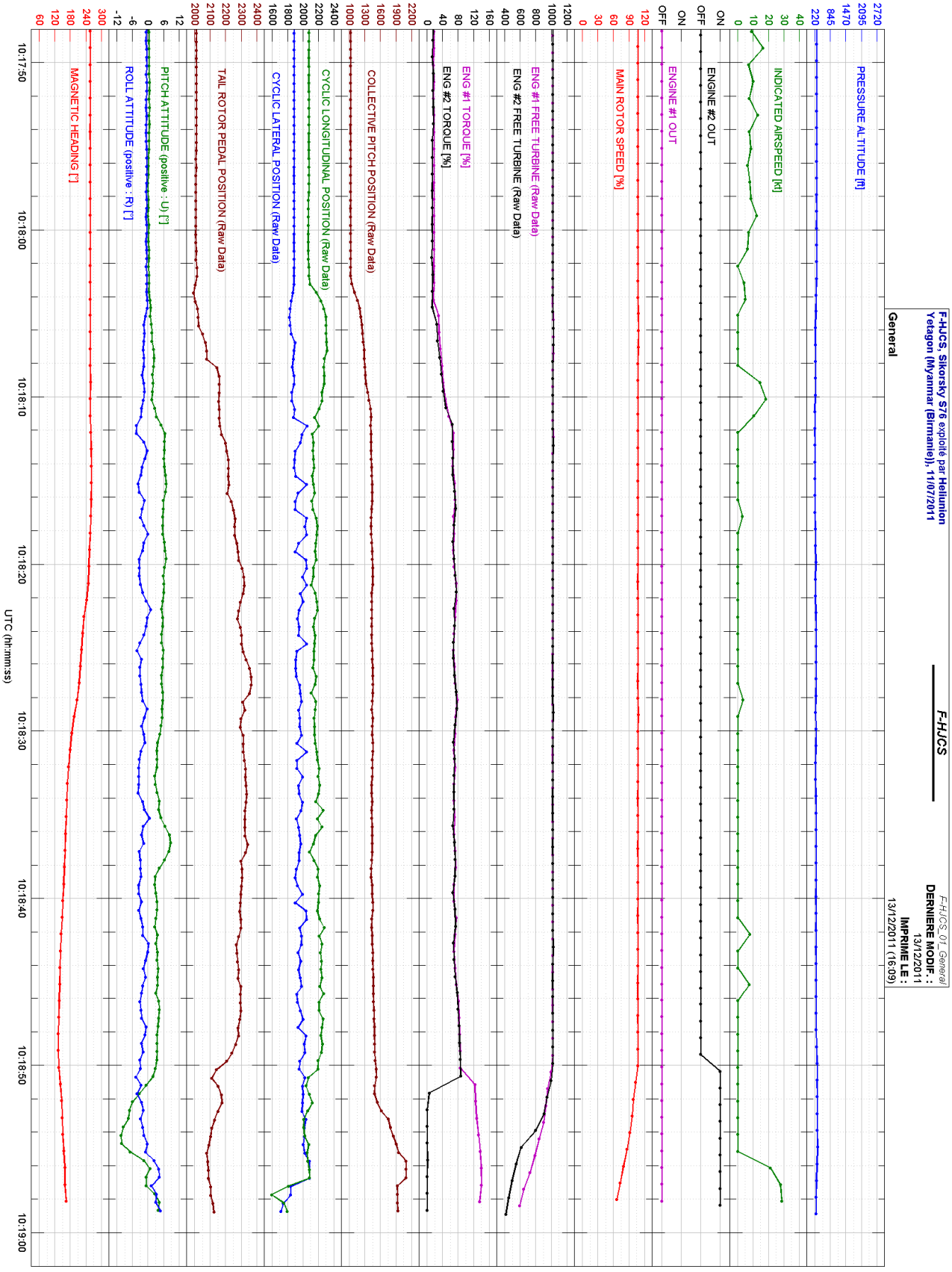
- a copy of the video of the recorder and ECU opening,
- a copy of the raw binary files, in Honeywell DLU format,
- the audio files corresponding to the four tracks and a built multi-audio project 'F-HJCS_SSCVR.VIP' file,
- a Samplitude 30 days trial version software,
- FDR dataframe, plots and listing.

All electronic boards are securely kept at the BEA.

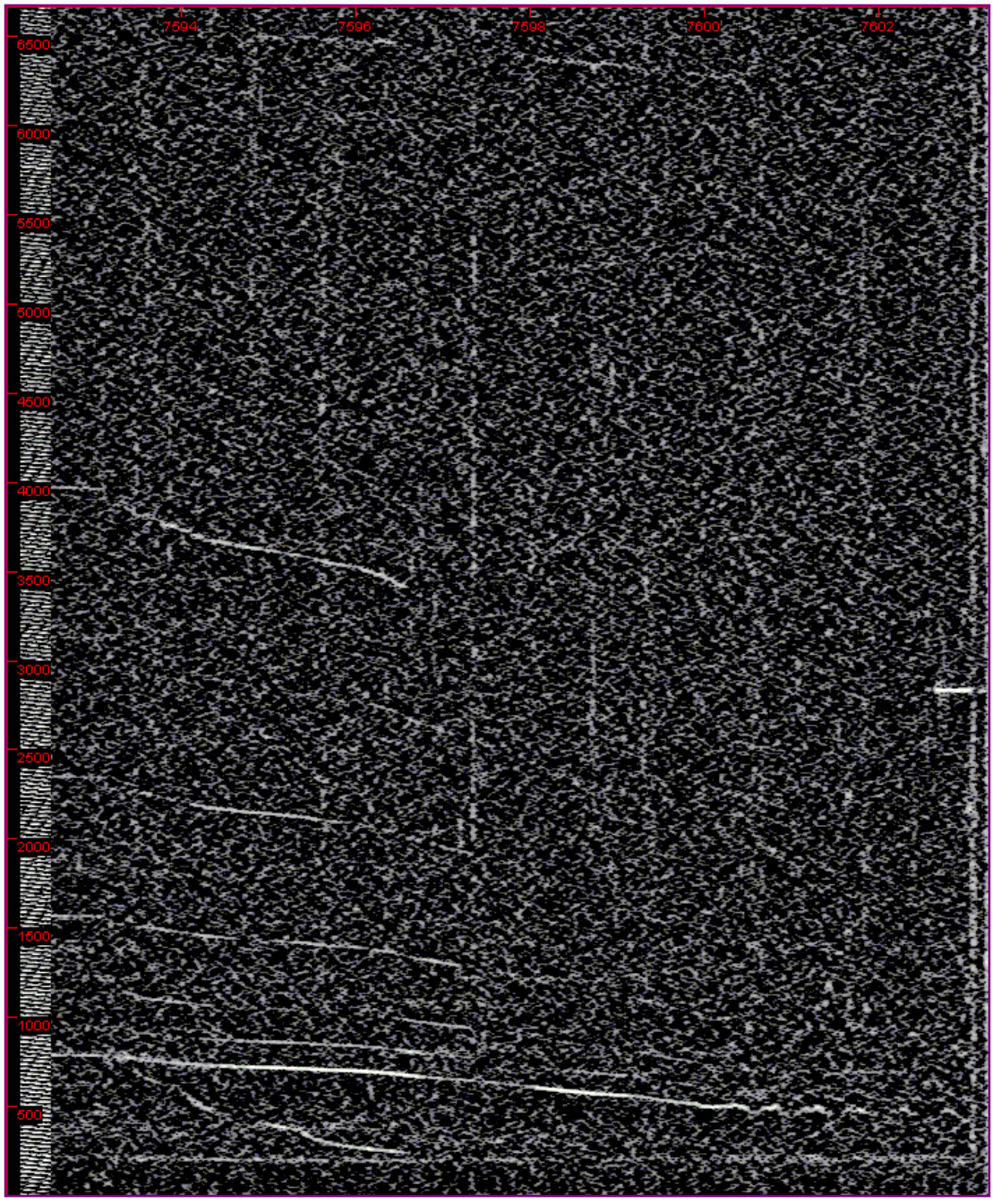
Appendices

Appendix 1: Plot of FDR data
Appendix 2: CVR CAM channel / spectral view of the last 11 seconds

APPENDIX 1: PLOT OF FDR DATA



APPENDIX 2: CVR CAM CHANNEL / SPECTRAL VIEW OF THE LAST 11 SECONDS



Spectrogram 0-6kHz - fft 2048pt – rec: 19s

BEA

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Local Time	Captain	First Officer	ATC, Ground, PNC	Remarks, sounds
08:12:17	Start of the recording			
10:10:56	Start of the transcription			
10:10:56	FSO on the left			
10:10:57		yes		
10:10:58	Ok we'll turn a little, ok ?			
10:11:01		Yes		
10:11:01	Clear on the left			
10:11:03		Yes		
10:11:06	(*)			
10:11:17		(floats safe) autopilot 1 and 2 off		
10:11:21			Yetagun FSO	
10:11:23	(finger, finger … yeah)			
10:12:07	We will take off that way			
10:12:10	We will take off that way			
10:12:13		Yes yes		
10:12:15		That way		
10:13:14		HLO Charlie Sierra		
10:13:17			Yes go ahead	
10:13:22			(*) four four one	
10:13:23	The door is open			
10:13:27		Yes		
10:15:02	The payload at take off			
10:15:05		Yes the take off is PC1, 10870 pounds		
10:15:10	Go ahead no problem			
10:15:18	And the rain is finished at Yetagun			
10:15:21		Yes no rain		
10:15:42	We will put one two, … one two hundred			
10:15:48		Yes		
10:15:49	Yes on YETA			
10:15:51	I think so, one two hundred, look			
10:15:57		One two hundred, one two hundred, this is, euh … one two hundred		
10:16:03	Good	Yes		

Local Time	Captain	First Officer	ATC, Ground, PNC	Remarks, sounds
10:16:06		One one six two four		
10:16:19		Ok before take off check		
10:16:21	eh			
10:16:22		Before moving landing light		
10:16:24	Off off			
10:16:25		Doors		
10:16:26	Closed no light			
10:16:27		Anti ice pitot heat, windshield heat		
10:16:29	Off	Off		
10:16:30		Before take off engine levers		
10:16:32	Two in fly			
10:16:33		Fuel levers		
10:16:34	direct			
10:16:35		Engines control lights		
10:16:36	Off			
10:16:37		Caution and warning lights		
10:16:38	(* only)			
10:16:39		DECU		
10:16:41	Is good			
10:16:42		Stick trim		
10:16:43	ON			
10:16:43		Three on autopilot		
10:16:44	One two	one two		
10:16:46		And parking brakes		
10:16:47	On			
10:16:48		Floats		
10:16:49	Armed			
10:16:50		Yes		
10:16:52	Ok I turn			
10:16:54	I take off and I give you the control			
10:16:56		Yes		
10:16:58	You can ask to Yetagun we take Off			
10:17:01		Foxtrott Charlie Sierra lifting now		

Local Time	Captain	First Officer	ATC, Ground, PNC	Remarks, sounds
10:17:08			(check lifting now)	
10:17:11		Green deck please Yetagun		
10:17:14			Charlie Sierra Yetagun helideck is cleared to land Sir	
10:17:18		Roger clear to land Charlie Sierra		
10:17:22	Ok good for you	It's clear		
10:17:24	(* Nav) … it's better huh Yetagun huh	Yes, yes		
10:17:35	(*) FSO			
10:17:37		huh FSO is four two nine		
10:17:39	Ok do			
10:17:42	Four two nine …	Yes		
	do it			
10:17:46	No no, no no			
10:17:53		What what is wrong with it		
10:17:55	(Donne) me, give me			(French)
10:18:00	Ok	Four two nine		
10:18:01	All right			
10:18:02	Finish	Ok		
10:18:08	Good for you			
10:18:09		yes		
10:18:12		Hovering now clear the net		
	Ok the deck is the net is ok			
10:18:14		Clear the net and sixty nose up		
10:18:18	Ok I turn			GPWS: SV "*be alert terrain inop*"
10:18:20		Temperature pressure normal, ninety five percent only		
10:18:23	yeah			
10:18:28	Like this huh, ok			
10:18:31		Yes ninety five percent		
10:18:35	Whoa whoa whoa			
		You can move to the left		

Local Time	Captain	First Officer	ATC, Ground, PNC	Remarks, sounds
10:18:36	Yes I can			
10:18:43	Ok take off			
10:18:44		Ok		
10:18:47		fifteen		
10:18:49		Twenty		
10:18:49,7		Twenty five feet		
10:18:50				Start of the engine out alarm
10:18:52	Whoa ?			
10:18:52,6	What is what, … what is what			
			Charlie Sierra	
10:18:56	(*)	(*)		
10:19:00	End of transcription			

SV: synthetic voice

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ALERT LETTER

CC/JSC/ML

Service Letter No. 2539/07/ARRIEL2/25 - 8th issue

This Service Letter supersedes the issue dated July 28, 2010

Subject: ARRIEL 2 - All variants. Rupture of the HP turbine blade.

Bordes, February 9, 2012

Dear Sir or Madam,

The purpose of this Service Letter update is to inform you of new occurrences of HP turbine blade ruptures. We confirm fourteen occurrences of HP turbine blade ruptures on ARRIEL 2 variants so far.

One of these cases occurred on an ARRIEL 2S2 engine fitted to a S76C++ helicopter and was subject to an accident. While the aircraft was taking off from a tanker, the pilot had to perform water landing in single engine configuration. Following the water landing, the aircraft capsized (ongoing formal investigation).

In addition, several cases of cracks on one or more ARRIEL 2 HP turbine blades were detected during non-destructive inspections at a Repair Center. In each of these cases, damage to the HP blades was not the reason for return of the associated module M03 to a Repair Center nor were there any operational consequences.

All the occurrences of HP blade cracks or ruptures mentioned in this Service Letter occurred on PRE TU 166 equipment.

The design of ARRIEL 2 engines (containment shield around the HP turbine) allows debris from a blade or the disk inter-blade area to be contained in the event of rupture. Due to this design, all blade fragments were completely contained in all listed cases. In all cases which occurred in flight on twin-engine applications, the remaining operating engine reached the OEI rating and delivered the expected power as planned.

Investigation of the equipment concerned and the in-depth causal analysis of the occurrences of HP blade rupture, allowed us to identify the most probable scenario that could lead to a rupture. Excitation of one of the vibration modes of the HP blade in conjunction with several secondary contributing factors is deemed sufficient to reduce the stress margin of the HP blade to a level consistent with the occurrences of ruptures encountered.

Except for the vibratory excitation of the HP blade, which may occur simultaneously on both engines of a twin-engine helicopter, contributing factors required to initiate a crack are intrinsic to each HP blade. Therefore, the risk of both engines shutting down in flight on a twin-engine helicopter is negligible and well within acceptable aeronautical standards.

ENR0651 E

Backed by this analysis, the following corrective actions have been implemented:

- Reinforcement of inspections performed on HP blades disassembled at a Repair Center by adding, among other things, a detailed binocular examination of the blade/disk contact surfaces. This inspection is associated with the implementation of acceptance criteria for damage identified on blade/disk contact surfaces.
- In order to minimize the effects of HP blade vibratory excitation and to increase the blade tolerance for this type of stress, modification TU 166 was developed (addition of a shock absorber in the inter-blade area under the platform).

Subject to Service Bulletins No. 292 72 2166 and No. A 292 72 3166, modification TU 166 is currently applied to new engines and upon first return of module M03 to a Repair Center on all ARRIEL 2 variants.

Modification TU 166 (SB No. 292 72 2166) is applied to the ARRIEL 2S2 variant upon receipt of parts sent to the operator during replacement of the HP turbine by an approved technician or upon first return to a Repair or Maintenance Center.

Application of modification TU 166 is mandatory on the ARRIEL 2 single-engine fleet. We remind you that modification TU 166 on single-engine helicopters is overseen by our NORIA teams and is subject to Mandatory SB No. A292 72 3166 which requires TU 166 to be applied before November 18, 2012. As a reminder, the information required to contact our NORIA teams is available on our TOOLS website in the dedicated NORIA section.

Please contact us if you require further information or assistance.

C. CANEILLES
Technical Support Department

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SERVICE LETTER

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JSV/FT/ML

Service Letter No. 2784/10/AR2S

Subject: ARRIEL 2 Si - S2 engines
Conditions of incorporation of modification TU 166.

Bordes, November 19, 2010

Dear Sir or Madam,

In addition to SL 2539/07/ARRIEL2/25 issue 7 and following Sikorsky Aircraft Corporation's issuance of their Safety Advisory SSA-S76-10-002, TURBOMECA would like to specify certain facts regarding occurrences of ruptures and cracks at the root of high pressure turbine blades reported on pre TU166 ARRIEL 2S1 and ARRIEL 2 S2 engines (SB 292 72 2166, addition of a damper in the interblade area under the platform).

Sikorsky Safety Advisory SSA-S76-10-002 contains the same information as SL 2539/07/ARRIEL2/25 except that it does not detail specific features of ARRIEL 2 S2 engines equipping S76 C++ helicopters:

The ARRIEL 2 S1 engine has logged 3.7 times as many flight hours as the ARRIEL 2 S2 with only one occurrence of rupture at the root of the high pressure turbine blade. Three occurrences of rupture and eight occurrences of cracks (observed during repair) at the root of the high pressure turbine blade have been reported to date on the ARRIEL 2 S2 variant equipping the S76 C++ helicopter.

These facts in addition to investigative and causal analysis studies have led us to prioritize the incorporation of modification TU 166 on ARRIEL 2 S2 engines. This modification is incorporated in accordance with incorporation code 2-1:

> Incorporation at the operator site, at a TURBOMECA-approved service center or at a TURBOMECA-approved maintenance center upon the receipt of parts sent by TURBOMECA,
> or
>
> Incorporation upon first return to a TURBOMECA-approved repair center whatever the reason for return.

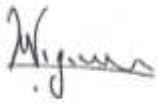
For the ARRIEL 2 S1 engine, modification TU 166 is incorporated in accordance with incorporation code 2-4:

> Incorporation at the operatbr site, at a TURBOMECA-approved service center or at a TURBOMECA-approved maintenance center if the high pressure turbine is being replaced.
>
> or

Incorporation upon first return to a TURBOMECA-approved repair center whatever the reason for return.

To date, all findings and data obtained from technical studies justify the aforementioned conditions of incorporation. We'll inform you immediately if any new information raises questions regarding our conclusions.

Please contact us if you require further information or assistance.



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SERVICE BULLETIN

ARRIEL 2

292722166

Objet: Module M03 (générateur). Amortisseurs pales HP.
Application de la modification TU 166.

Les informations techniques contenues dans le présent document ont été approuvées sous couvert du certificat d'Agrément de Conception n°EASA.21J.070.

Version: F

Raison de la mise à jour: Mise à jour de la liste des fournitures.

1. Données d'application

Date d'applicabilité de la modification *	AVRIL 2009

* Date à partir de laquelle les conditions d'application de la modification (définies dans le § A) objet du présent SB, doivent être systématiquement respectées.
Cette date correspond à la disponibilité suffisante de l'ensemble des moyens (pièces, outillages, documentation...) permettant de l'appliquer.
Dans le cas de disponibilité anticipée de ces moyens, la modification peut être appliquée à titre exceptionnel avant la date d'applicabilité.

A. Application

Le constructeur considère que la modification indiquée doit être appliquée en stricte conformité avec les conditions d'application définies dans ce Service Bulletin (SB).

Validité	Code
ARRIEL 2S2	2-1

Nota : Pour l'application de la modification TU 166 sur les variantes ARRIEL 2B - 2B1 - 2B1A, se référer au SB n° A292 72 3166.

Conditions d'application sur les moteurs en service

(1) Application chez l'utilisateur, dans un Centre de Service agréé par TURBOMECA ou dans un Centre de Maintenance agréé par TURBOMECA
Dès réception des pièces envoyées par TURBOMECA.

(2) Application dans un Centre de Réparation agréé par TURBOMECA
Au premier retour dans un Centre de Réparation agréé quelle que soit la cause de retour.

Validité	Code
ARRIEL 2C - 2C1 - 2C2 ARRIEL 2S1	2-4

Conditions d'application sur les moteurs en service

(3) Application chez l'utilisateur, dans un Centre de Service agréé par TURBOMECA ou dans un Centre de Maintenance agréé par TURBOMECA
Si remplacement de l'ensemble Turbine Haute Pression (THP).

(4) Application dans un Centre de Réparation agréé par TURBOMECA
Au premier retour dans un Centre de Réparation agréé quelle que soit la cause de retour.

B. But

Améliorer l'amortissement vibratoire des pales HP et limiter le débattement axial de la pale HP par rapport au disque en cas de rupture ou d'ouverture d'un frein de pale.

C. Description (voir Figure)

Cette modification consiste à introduire des amortisseurs entre les pales et le disque HP.

D. Approbation

Les informations techniques contenues dans le présent document ont été approuvées sous couvert du certificat d'Agrément de Conception n° EASA.21J.070.

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SERVICE BULLETIN

E. Main d'œuvre

(1) Chez l'utilisateur, dans un Centre de Service agréé par TURBOMECA ou dans un Centre de Maintenance agréé par TURBOMECA

(a) Par l'utilisateur
1 Personnel : 1 mécanicien.
2 Temps nécessaire : 12 heures-homme (dépose/pose du module M03).

(b) Par un technicien qualifié par TURBOMECA
1 Personnel : 1 technicien qualifié par TURBOMECA pour cette intervention.
2 Temps nécessaire : se reporter à l'ITM Réf. X 292 M1 308 1.

(2) Dans un Centre de Réparation agréé par TURBOMECA
(a) Personnel du Centre de Réparation agréé.
(b) Temps défini par le Centre de Réparation pour ce niveau d'intervention.

F. Matériel

Voir paragraphe 3.

G. Outillage

(1) Chez l'utilisateur, dans un Centre de Service agréé par TURBOMECA ou dans un Centre de Maintenance agréé par TURBOMECA

(a) Pour l'utilisateur
- Outillage standard de mécanicien.
- Outillage de dépose/pose du module M03.

(b) Pour un technicien qualifié par TURBOMECA
Se reporter à l'ITM Réf. X 292 M1 308 1.

(2) Dans un Centre de Réparation agréé par TURBOMECA
Se reporter au Manuel de Révision ARRIEL 2 concerné.

H. Masse et centrage

Sans objet.

I. Références

(1) Manuel de Maintenance ARRIEL 2C ..... Réf. X 292 M1 450 1.
(2) Manuel de Maintenance ARRIEL 2C1 ..... Réf. X 292 N4 450 1.
(3) Manuel de Maintenance ARRIEL 2C2 ..... Réf. X 292 N6 450 1.
(4) Manuel de Maintenance ARRIEL 2S1 ..... Réf. X 292 L0 301 1.
(5) ARRIEL 2S2 Maintenance Manual ..... Réf. X 292 P5 451 2.
(6) Manuel de Révision ARRIEL 2C ..... Réf. X 292 M1 500 1.
(7) Manuel de Révision ARRIEL 2C1 ..... Réf. X 292 N4 500 1.
(8) Manuel de Révision ARRIEL 2C2 ..... Réf. X 292 N6 500 1.
(9) Manuel de Révision ARRIEL 2S1 ..... Réf. X 292 L0 500 1.
(10) Manuel de Révision ARRIEL 2S2 ..... Réf. X 292 P5 500 1.
(11) Instruction Technique de Maintenance ..... Réf. X 292 M1 308 1.
(12) Service Bulletin ..... N° 292 72 2164.
(13) Manuel de Maintenance de l'hélicoptère concerné.

J. Autres documents concernés

(1) Catalogue de Rechanges ARRIEL 2C ..... Réf. X 292 M1 700 1.
(2) Catalogue de Rechanges ARRIEL 2C1 ..... Réf. X 292 N4 700 1.
(3) Catalogue de Rechanges ARRIEL 2C2 ..... Réf. X 292 N6 700 1.
(4) Catalogue de Rechanges ARRIEL 2S1 ..... Réf. X 292 L0 700 1.
(5) ARRIEL 2S2 Maintenance Spares Parts Catalog ..... Réf. X 292 P5 700 2.

(6) Tableau de Composition Illustré ARRIEL 2C..... Réf. X 292 M1 600 1.
(7) Tableau de Composition Illustré ARRIEL 2C1..... Réf. X 292 N4 600 1.
(8) Tableau de Composition Illustré ARRIEL 2C2..... Réf. X 292 N6 600 1.
(9) Tableau de Composition Illustré ARRIEL 2S1..... Réf. X 292 L0 600 1.
(10) Tableau de Composition Illustré ARRIEL 2S2..... Réf. X 292 P5 600 1.

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SERVICE BULLETIN

2. Conditions d'exécution

A. Mise en œuvre

L'application de cette modification nécessite la dépose du moteur.

(1) Chez l'utilisateur, dans un Centre de Service agréé par TURBOMECA ou dans un Centre de Maintenance agréé par TURBOMECA

(a) Par l'utilisateur

Par remplacement du module M03.

(b) Par un technicien qualifié par TURBOMECA

Par remplacement de l'ensemble roue de turbine HP.

(2) Dans un Centre de Réparation agréé par TURBOMECA

Par modification de l'ensemble roue de turbine HP.

B. Mode opératoire

(1) Chez l'utilisateur, dans un Centre de Service agréé par TURBOMECA ou dans un Centre de Maintenance agréé par TURBOMECA

(a) Par l'utilisateur

1 Déposer le module M03 pre TU 166 : se reporter au Manuel de Maintenance ARRIEL 2 concerné, tâche 72-00-43-900-801.

2 Renvoyer le module M03 pre TU 166 avec sa Fiche Matricule de Fourniture Echangeable (FMFE) mise à jour dans un Centre de Réparation ou dans un Centre de Maintenance agréé par TURBOMECA.

3 Poser un module M03 post TU 166 : se reporter au Manuel de Maintenance ARRIEL 2 concerné, tâche 72-00-43-900-801.

(b) Par un technicien qualifié par TURBOMECA

1 Déposer l'ensemble roue de turbine HP pre TU 166 : se reporter à l'ITM Réf. X 292 M1 308 1.

2 Renvoyer l'ensemble roue de turbine HP pre TU 166 dans un Centre de Réparation agréé par TURBOMECA.

3 Poser un ensemble roue de turbine HP post TU 166 : se reporter à l'ITM Réf. X 292 M1 308 1.

4 Dans le cas où l'intervention de remplacement de la turbine HP est réalisée chez l'utilisateur, si les résultats du contrôle santé moteur sont disponibles, renseigner les marges en couple et T45 dans l'attestation en Annexe 2 (ARRIEL 2S2) ou Annexe 4 (ARRIEL 2C - 2C1 - 2C2 - 2S1) de ce SB.

(2) Dans un Centre de Réparation agréé par TURBOMECA

Se reporter au Manuel de Révision ARRIEL 2 concerné.

C. Remise en condition et contrôles

(1) Chez l'utilisateur, dans un Centre de Service agréé par TURBOMECA ou dans un Centre de Maintenance agréé par TURBOMECA

(a) Par l'utilisateur

1 Effectuer un point fixe de contrôle : se reporter au Manuel de Maintenance ARRIEL 2 concerné, tâche 71-02-13-280-801.

2 Effectuer un contrôle des vibrations : se reporter au Manuel de Maintenance ARRIEL 2 concerné, tâche 71-02-10-760-801.

3 Effectuer un contrôle de la pression d'huile : se reporter au Manuel de Maintenance ARRIEL 2 concerné, tâche 79-00-00-200-801.

(b) Par un technicien qualifié par TURBOMECA

Se reporter à l'ITM Réf. X 292 M1 308 1.

(2) Dans un Centre de Réparation agréé par TURBOMECA

Se reporter au Manuel de Révision ARRIEL 2 concerné.

D. Identification

(1) Chez l'utilisateur, dans un Centre de Service agréé par TURBOMECA ou dans un Centre de Maintenance agréé par TURBOMECA

(a) Par l'utilisateur

1 Renseigner le livret moteur ("actuel" ou "unique") de la façon suivante :

1.1 Sur le livret moteur "actuel" :
- Section "B" : enregistrer le remplacement du module M03.
- Section "D" : mettre à jour l'état de disponibilité.
- Section "E" : enregistrer le remplacement du module M03 avec mise à jour de l'état de disponibilité.
- Mettre à jour la FMFE du module M03 déposé et la FMFE du module M03 posé.

1.2 Sur le livret moteur "unique" :
- Section "B" : enregistrer le remplacement du module M03.
- Section "E" : enregistrer le remplacement du module M03 avec mise à jour de l'état de disponibilité.
- Mettre à jour la FMFE du module M03 déposé et la FMFE du module M03 posé.

2 Informer TURBOMECA du remplacement du module M03 en renvoyant, dûment complétée, l'attestation présentée en Annexe 1 (ARRIEL 2S2) ou Annexe 3 (ARRIEL 2C - 2C1 - 2C2 - 2S1) de ce SB.

(b) Par un technicien qualifié par TURBOMECA

1 Enregistrer l'application de la modification TU 166, par application de l'ITM Réf. X 292 M1 308 1 sur la FMFE du module M03 modifié.

2 Renvoyer le rapport technique de l'ITM Réf. X 292 M1 308 1.

3 Informer TURBOMECA de l'application de la modification TU 166 en renvoyant, dûment complétée, l'attestation présentée en Annexe 2 (ARRIEL 2S2) ou Annexe 4 (ARRIEL 2C - 2C1 - 2C2 - 2S1) de ce SB accompagnée d'une copie de la fiche de composition des pales de la turbine HP si disponible dans le livret moteur.

(2) Dans un Centre de Réparation agréé par TURBOMECA

(a) Sur le livret moteur, enregistrer l'application du SB n° 292 72 2166 correspondant à la modification TU 166 sur la FMFE du module M03 modifié.

(b) Informer TURBOMECA de l'application de la modification TU 166 en renvoyant, dûment complétée, l'attestation présentée en Annexe 2 (ARRIEL 2S2) ou Annexe 4 (ARRIEL 2C - 2C1 - 2C2 - 2S1) de ce SB.

E. Maintenance périodique

Sans objet.

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SERVICE BULLETIN

3. Informations concernant les fournitures

A. Elément de base

La fourniture nécessaire à l'application du présent SB est établie pour un moteur.

B. Liste des fournitures

Nota : Lors de l'application de la modification TU 166, la modification TU 164 (SB n° 292 72 2164) sera appliquée conjointement.

(1) Chez l'utilisateur, dans un Centre de Service agréé par TURBOMECA ou dans un Centre de Maintenance agréé par TURBOMECA

(a) Pour l'utilisateur

Module M03 post TU 166.

(b) Pour un technicien qualifié par TURBOMECA

Nouvelle référence	Lég.	Qté	Désignation	Prix	Ancienne référence	Lég.	Qté
ARRIEL 2C – 2C1 – 2S1							
0 292 26 049 0 0 292 26 050 0 0 292 26 051 0 0 292 26 053 0 0 292 26 054 0 0 292 26 055 0 7 292 26 720 C	A	1	Ensemble roue de turbine HP	*	Toutes références	F	1
ARRIEL 2C2							
0 292 26 048 0 0 292 26 052 0 7 292 26 052 A 7 292 26 052 B	A	1	Ensemble roue de turbine HP	*	Toutes références	F	1
ARRIEL 2S2							
0 292 26 048 0 0 292 26 052 0 7 292 26 052 A	A	1	Ensemble roue de turbine HP	*	Toutes références	F	1

Légende

A - Pièce incorporée par la modification.

F - Pièce modifiable chez le fabricant ou par un Centre de Réparation agréé par TURBOMECA.

** - Les prix seront communiqués sur demande.*

(2) Dans un Centre de Réparation agréé par TURBOMECA

Nouvelle référence	Lég.	Qté	Désignation	Ancienne référence	Lég.	Qté
0 292 26 024 0	A	39	Amortisseur			

Légende

A - Pièce incorporée par la modification.

C. Modalités d'approvisionnement

ARRIEL 2S2

L'approvisionnement des pièces sera géré par :

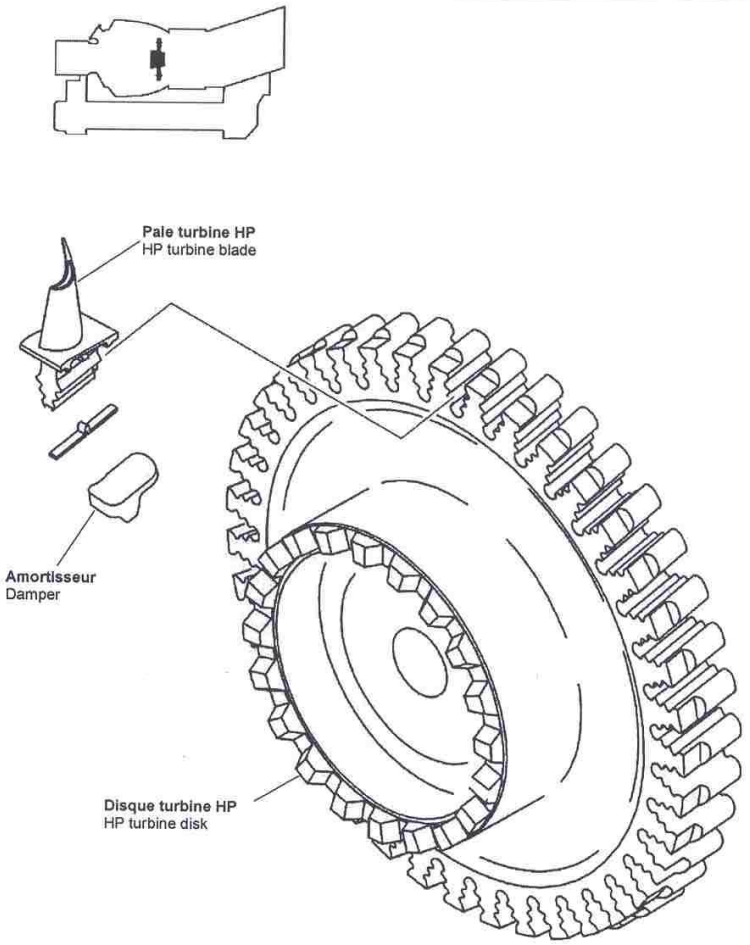
For Africa, Europe, Middle East **TURBOMECA-Noria** **Team Tarnos** DVO Service NORIA 40220 TARNOS – France Fax:+33 (0) 5 59 74 45 72 noria-tarnos-arriel2@turbomeca.fr	**For Australasia** **TURBOMECA-Noria** **Team Sydney** 115 Wackett St, Bankstown Airport Bankstown, NSW 2200 - Australia Fax: +61 2 9791 6708 noria-sydney@turbomeca.com.au
For North America **TURBOMECA-Noria** **Team Dallas** 2709 Forum Drive Grand Prairie, TX 75052 – USA Fax : +1 972 606 76 68 noria-dallas@turbomeca.com	**For South America** **TURBOMECA-Noria** **Team Rio** Rua Capitão Guynemer, 1626 - Xerém CEP : 25250-130 - Duque de Caxias - RJ - Brasil Fax : +55 21 2679 2794 noria-rio@turbomeca.com.br

ARRIEL 2C - 2C1 - 2C2 - 2S1

Commande suivant les besoins à :
un point de réseau TURBOMECA
ou
TURBOMECA
Direction Support Ventes Opérateurs
Département Commercial
40220 TARNOS
France
Fax n° +33 (0) 5 59 74 45 11.

SAFRAN Turbomeca

SERVICE BULLETIN



FIGURE

SAFRAN
Turbomeca

SERVICE BULLETIN

Objet : ARRIEL 2S2
Attestation de remplacement du module M03.

Subject: ARRIEL 2S2
Compliance certificate for replacement of module M03.

Important / Important notice :
Après application des instructions spécifiées dans ce SB, veuillez compléter la présente attestation et la retourner par courrier ou courriel ou fax à (cf §3.C) :
After application of the instructions specified in this SB, please complete this certificate and mail or email or fax it to (refer to §3.C):

For Africa, Europe, Middle East **TURBOMECA-Noria (Team Tarnos)** Fax:+33 (0) 5 59 74 45 72 noria-tarnos-arriel2@turbomeca.fr	**For Australasia** **TURBOMECA-Noria (Team Sydney)** Fax: +61 2 9791 6708 noria-sydney@turbomeca.com.au
For North America **TURBOMECA-Noria (Team Dallas)** Fax : +1 972 606 76 68 noria-dallas@turbomeca.com	**For South America** **TURBOMECA-Noria (Team Rio)** Fax : +55 21 2679 2794 noria-rio@turbomeca.com.br

Information concernant le matériel / Equipment information

Utilisateur Customer				**N° Appareil** Aircraft S/N		
	N/S - S/N	**Réf.** - P/N	**TSN***	**TSO***	**CSN***	**CSO***
Moteur Engine						
Module M03 déposé Removed module M03						
Module M03 posé Installed module M03						

* **TSN = Time Since New** (Heures depuis neuf) **CSN = Cycles Since New** (Cycles depuis neuf)
TSO = Time Since Overhaul (Heures depuis RG) **CSO = Cycles Since Overhaul** (Cycles depuis RG)

Opération effectuée par : Work performed by:	

Je certifie que le module identifié ci-dessus a été installé selon les directives de ce SB.
I certify that the above-mentioned module has been installed according to the directives given in this SB.

Date	**Nom** / Print name	**Fonction** / Job title

Signature :

ANNEXE 1 / APPENDIX 1

SAFRAN
Turbomeca

SERVICE BULLETIN

Objet : ARRIEL 2S2 - Attestation d'application de la modification TU 166.
Subject: **ARRIEL 2S2** - Modification TU 166 compliance certificate.

Important / Important notice :
Après application des instructions spécifiées dans ce SB, veuillez compléter la présente attestation et la retourner par courrier ou courriel ou fax à (cf §3.C) :
After application of the instructions specified in this SB, please complete this certificate and mail or email or fax it to (refer to §3.C):

For Africa, Europe, Middle East **TURBOMECA-Noria (Team Tarnos)** Fax:+33 (0) 5 59 74 45 72 noria-tarnos-arriel2@turbomeca.fr	**For Australasia** **TURBOMECA-Noria (Team Sydney)** Fax: +61 2 9791 6708 noria-sydney@turbomeca.com.au
For North America **TURBOMECA-Noria (Team Dallas)** Fax : +1 972 606 76 68 noria-dallas@turbomeca.com	**For South America** **TURBOMECA-Noria (Team Rio)** Fax : +55 21 2679 2794 noria-rio@turbomeca.com.br

Information concernant le matériel / Equipment information

Utilisateur Customer				**N° Appareil** Aircraft S/N		
	N/S - S/N	**Réf.** - P/N	**TSN***	**TSO***	**CSN***	**CSO***
Moteur Engine						
Module M03 modifié Modified module M03						
Turbine HP déposée Removed HP turbine						
Disque HP HP disk						
Pales HP HP blades						
Fiche de composition de la turbine HP déposée Distribution sheet of removed HP turbine			**Oui** Yes ☐		**Non** No ☐	
Turbine HP posée Installed HP turbine						

* **TSN = Time Since New (Heures depuis neuf)** **CSN = Cycles Since New (Cycles depuis neuf)**
TSO = Time Since Overhaul (Heures depuis RG) **CSO = Cycles Since Overhaul (Cycles depuis RG)**

Contrôle Santé Moteur si résultats disponibles Engine power check if results available	**Marge en couple** Torque margin	%	**Marge en T45** T45 margin °C
Cocher si pièce remplacée durant la même intervention Check if part is replaced during the same intervention	**Roue d'injection** Injection wheel ☐		**Segments de l'anneau de THP** HPT ring segments ☐

Opération effectuée par : Work performed by:	

Je certifie que le module identifié ci-dessus a été modifié selon les directives de ce SB.
I certify that the above-mentioned module has been modified according to the directives given in this SB.

Date	**Nom** / Print name	**Fonction** / Job title

Signature :

ANNEXE 2 / APPENDIX 2

SAFRAN
Turbomeca

SERVICE BULLETIN

Objet : ARRIEL 2C - 2C1 - 2C2 - 2S1
Attestation de remplacement du module M03.

Subject: ARRIEL 2C - 2C1 - 2C2 - 2S1
Compliance certificate for replacement of module M03.

Important / Important notice :
Après application des instructions spécifiées dans ce SB, veuillez compléter la présente attestation et la retourner par courrier ou courriel ou fax à :
After application of the instructions specified in this SB, please complete this certificate and mail or email or fax it to:

TURBOMECA
Equipe Administration Base installée / Fleet Data Administrator Team
Bâtiment 3 – BP 59
40220 TARNOS – France
Fax n° / No. +33 (0) 5 59 74 46 95
Email : fleetdata@turbomeca.fr

Information concernant le matériel / Equipment information						
Utilisateur Customer				**N° Appareil** Aircraft S/N		
	N/S - S/N	**Réf.** - P/N	**TSN***	**TSO***	**CSN***	**CSO***
Moteur Engine						
Module M03 déposé Removed module M03						
Module M03 posé Installed module M03						

* **TSN = Time Since New** (Heures depuis neuf) **TSO = Time Since Overhaul** (Heures depuis RG)
CSN = Cycles Since New (Cycles depuis neuf) **CSO = Cycles Since Overhaul** (Cycles depuis RG)

Opération effectuée par : Work performed by:	

Je certifie que le module identifié ci-dessus a été installé selon les directives de ce SB.
I certify that the above-mentioned module has been installed according to the directives given in this SB.

Date	**Nom** / Print name	**Fonction** / Job title

Signature :

ANNEXE 3 / APPENDIX 3

SAFRAN
Turbomeca

SERVICE BULLETIN

Objet : ARRIEL 2C - 2C1 - 2C2 - 2S1
Attestation d'application de la modification TU 166.

Subject: ARRIEL 2C - 2C1 - 2C2 - 2S1
Modification TU 166 compliance certificate.

Important / Important notice :
Après application des instructions spécifiées dans ce SB, veuillez compléter la présente attestation et la retourner par courrier ou courriel ou fax à :
After application of the instructions specified in this SB, please complete this certificate and mail or email or fax it to:

TURBOMECA
Equipe Administration Base installée / Fleet Data Administrator Team
Bâtiment 3 – BP 59
40220 TARNOS – France
Fax n° / No. +33 (0) 5 59 74 46 95
Email : fleetdata@turbomeca.fr

Information concernant le matériel / Equipment information						
Utilisateur Customer				**N° Appareil** Aircraft S/N		
	N/S - S/N	**Réf.** - P/N	**TSN***	**TSO***	**CSN***	**CSO***
Moteur Engine						
Module M03 modifié Modified module M03						
Turbine HP déposée Removed HP turbine						
Disque HP HP disk						
Pales HP HP blades						
Fiche de composition de la turbine HP déposée Distribution sheet of removed HP turbine			**Oui** Yes ☐		**Non** No ☐	
Turbine HP posée Installed HP turbine						

* **TSN = Time Since New (Heures depuis neuf)** **TSO = Time Since Overhaul (Heures depuis RG)**
CSN = Cycles Since New (Cycles depuis neuf) **CSO = Cycles Since Overhaul (Cycles depuis RG)**

Contrôle Santé Moteur si résultats disponibles Engine power check if results available	**Marge en couple** Torque margin %	**Marge en T45** T45 margin °C
Cocher si pièce remplacée durant la même intervention Check if part is replaced during the same intervention	**Roue d'injection** Injection wheel ☐	**Segments de l'anneau de THP** HPT ring segments ☐
Opération effectuée par : Work performed by:		

Je certifie que le module identifié ci-dessus a été modifié selon les directives de ce SB.
I certify that the above-mentioned module has been modified according to the directives given in this SB.

Date	**Nom** / Print name	**Fonction** / Job title

Signature :

ANNEXE 4 / APPENDIX 4

- MAIB and BEA recommend that EASA study a method for release of rates of which it is aware and as soon as these rates get close to acceptable limits or show significant evolution.

- Consequently, MAIB recommends that the national authorities encourage the implementation of the procedures described in the ERP.

(Win Swe Tun)
Investigator- In-Charge
MAIB

DEPUTY DIRECTOR GENERAL
DEPARTMENT OF CIVIL AVIATION