الهيئة العامة للطيران المدني
GENERAL CIVIL AVIATION AUTHORITY

United Arab Emirates

# Air Accident Investigation Sector

## Accident

## - Final Report -

AAIS Case Nº: AIFN/0011/2023

# Controlled Flight Into Terrain (CFIT) (Sea Impact)

| | |
|---|---|
| Operator: | Aerogulf Services |
| Aircraft Type: | Bell Textron Bell 212 Helicopter |
| Registration: | A6-ALD |
| State of Operator: | United Arab Emirates |
| Place of Occurrence: | Close to ARAS Driller Rig, Umm Al Quwain |
| Date of Occurrence: | 7 September 2023 |

This Investigation was conducted by the Air Accident Investigation Sector of the United Arab Emirates pursuant to the United Arab Emirates Federal Act No. 20 of 1991, promulgating the Civil Aviation Law, in compliance with Air Accident and Incident Investigation Regulation, and in conformance with the provisions of Annex 13 to the Convention on International Civil Aviation.

This Investigation was conducted independently and without prejudice. The sole objective of the investigation is to prevent future aircraft accidents and incidents. It is not the purpose of this activity to apportion blame or liability.

The Air Accident Investigation Sector of the United Arab Emirates issued this Final Report in accordance with national and international standards and best practice. Consultation with applicable stakeholders, and consideration of their comments, took place prior to the publication of this Report.

The Final Report is publicly available at:

https://www.gcaa.gov.ae/en/departments/airaccidentinvestigation/Pages/InvestigationReports.aspx

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# Occurrence Brief

| | | |
|---|---|---|
| Occurrence Reference | : | AIFN/0011/2023 |
| Occurrence Classification | : | Accident |
| Name of the Operator | : | Aerogulf Services Co (LLC) |
| Manufacturer | : | Bell Textron Inc. |
| Helicopter Model | : | Bell 212 |
| Engines | : | Twin-Engines PT6T-3B Pratt & Whitney Canada |
| Nationality | : | The United Arab Emirates |
| Registration Marks | : | A6-ALD |
| Manufacturer Serial Number | : | 30809 |
| Year of Manufacture | : | 1976 |
| Flight Hours Since New | : | 27,850.70 |
| Cycles Since New | : | 31,591 |
| Type of Flight | : | Non-revenue training flight |
| State of Occurrence | : | The United Arab Emirates |
| Place of Occurrence | : | Close to ARAS Driller Rig, Umm Al Quwain |
| Date and Time | : | 7 September 2023, at 2008 LT of the United Arab Emirates |
| Total Crewmembers | : | Two pilots |
| Total Passengers | : | None |
| Injuries to Crew | : | Two pilots (fatal) |
| Other Injuries | : | None |
| Nature of Damage | : | Destroyed |

# Investigation Objective

This investigation was conducted pursuant to the United Arab Emirates Federal Act No. 20 of 1991, promulgating the Civil Aviation Law, Chapter VII – Aircraft Accidents, Article 48. It is in compliance with the *Air Accident and Incident Investigation Regulation (AAIR)* and in conformity with Annex 13 to the Convention on International Civil Aviation.

The sole objective of this investigation is to prevent aircraft accidents and incidents. It is not the intent of this activity to apportion blame or liability.

# Investigation Process

The occurrence involved a Bell 212, registration marks A6-ALD, and was notified to the Air Accident Investigation Sector (AAIS) by phone call to the Duty Investigator (DI) hotline number +971506414667, at 2054 LT. The Occurrence was notified by the Safety Manager, Aerogulf Services.

The occurrence was classified as 'Accident' according to the definition of Annex 13 to the Chicago Convention, and the AAIS opened Accident Investigation File Number

AIFN/0011/2023 for the case. The AAIS formed the investigation team led by the investigator-in-charge (IIC) and members from the AAIS for different investigation areas. The National Transportation Safety Board (NTSB) of the United States, being the State of the Manufacture and Design, and the Transportation Safety Board of Canada, being the State of engine manufacture, were notified of the Accident and both States assigned accredited representatives assisted by advisers from Bell Textron Inc. and Pratt & Whitney. In addition, an adviser from the Operator and two subject matter experts, holding the position of helicopter captain, from within the aviation sector of the United Arab Emirates, were designated to provide technical support to the IIC following the AAIS policies and procedures and in accordance with the investigation data and information protection requirements.

Notes:

1. Whenever the following words are mentioned in this Report, with first Capital letter, they shall mean the following:
   - (Accident). This investigated accident
   - (Instructor). The instructor pilot of the accident flight (left seat)
   - (Helicopter). The helicopter involved in this accident
   - (Investigation). The investigation into the circumstances of this accident
   - (Pilot Undergoing Route Familiarization “Pilot”). The pilot who was under his first familiarization flight on B212 night operation to the Rig (right seat)
   - (Report). This Final Report
   - (Rig). ARAS Driller Rig located offshore Umm Al Quwain, the United Arab Emirates.
2. Unless otherwise mentioned, all times in this Report are United Arab Emirates local time (LT) (LT equals UTC plus 4 hours).
3. Photos and figures used in this Report are taken from different sources and are adjusted from the original for the sole purpose to improve the clarity of the Report. Modifications to images used in this Report are limited to cropping, magnification, file compression, or enhancement of color, brightness, contrast, or addition of text boxes, arrows or lines.

# Abbreviations

| | |
|---|---|
| **AAIR** | *Air Accident and Incident Investigation Regulation* of the United Arab Emirates |
| **AAIS** | The Air Accident Investigation Sector of the United Arab Emirates |
| **ADI** | Attitude directional indicator |
| **AFCS** | Automatic flight control system |
| **AFCU** | Automatic fuel control unit |
| **ALF** | After last flight |
| **AOC** | Air operator certificate |
| **ARAS** | The Driller Rig |
| **ARC** | Airworthiness review certificate |
| **ATPL-H** | Air transport pilot license-Helicopter |
| **ATTD** | Attitude |
| **BOV** | Compressor bleed valve |
| **CAR** | Civil aviation regulation |
| **CFIT** | Controlled flight into terrains |
| **CRM** | Crew resource management |
| **CSI** | Cycles since installed |
| **CSN** | Cycles since new |
| **CVR** | Cockpit voice recorder |
| **DWC** | Al Maktoum International Airport |
| **EFS** | Emergency float system |
| **ELT** | Emergency locator transmitter |
| **ESN** | Engine serial number |
| **FDR** | Flight data recorder |
| **FDP** | Flight duty period |
| **FDTL** | Flight duty time limitation |
| **FP** | Flying pilot |
| **FPM** | Feet per minute |
| **FRMS** | Fatigue risk management system |
| **FSTD** | Flight simulation training devise |
| **FTIR** | Fourier-transform infrared spectroscopy |
| **GCAA** | The General Civil Aviation Authority of the United Arab Emirates |
| **GW** | Gross weight |
| **HDG** | Heading |
| **HLO** | Helideck landing officer |
| **HOFO** | Helicopter offshore operations |

| | |
|---|---|
| **IFR** | Instrument flight rule |
| **IIC** | Investigator-in-charge |
| **IR** | Instrument rating |
| **ITT** | Interstage turbine temperature |
| **kts** | knots |
| **KIAS** | Knots indicated airspeed |
| **lbs** | pounds |
| **LOC** | Localizer |
| **LOC-I** | Loss of control - Inflight |
| **LT** | Local time |
| **LTC** | Line training captain |
| **MP** | Multi-pilot |
| **MSN** | Manufacturer serial number |
| **MFCU** | Manual fuel control unit |
| **NFP** | Non-flying pilot |
| **NM** | nautical mile |
| **No.** | Number |
| **NR** | Main rotor RPM |
| **NTSB** | The National Transportation Safety Board of the United States |
| **OFP** | Operational flight plan |
| ***OM*** | *Operations manual* |
| **OMDW** | ICAO code of AL Maktoum International Airport |
| **PF** | Pilot flying |
| **PM** | Pilot monitoring |
| **PT** | Power turbine |
| **PDC** | Pre-departure check |
| **RADALT** | Radar altimeter |
| **RFM** | *Rotorcraft flight manual* |
| **ROC** | Rate of climb |
| **RP** | Rotation point |
| **RPM** | Revolutions per minute |
| **TCU** | Torque control unit |
| **TSI** | Time since installed |
| **TSN** | Time since new |
| **TSO** | Time since overhaul |
| **UTC** | Coordinated universal time |

| | |
|---|---|
| **VFR** | Visual flight rules |
| **VHF** | Very high frequency |
| **Vne** | Never exceed speed |
| **VOR** | Very high frequency (VHF) omni-directional range |
| **VSI** | Vertical speed indicator |
| **VTOCS** | Takeoff Climb Out Speed |
| **Vtoss** | Takeoff climb out speed |
| **Vy** | Speed that gives the best rate of climb |

# Synopsis

On 7 September 2023, a Bell Textron Bell 212 helicopter, registration marks A6-ALD, operated by Aerogulf Services Co. (LLC), was conducting a non-revenue night training flight from Al Maktoum International Airport (OMDW), Dubai, to the ARAS Driller Rig located offshore Umm Al Quwain, the United Arab Emirates. Two flight crewmembers were on board encompassing an instructor pilot on the left seat and a pilot undergoing route familiarization on the right seat.

During the third circuit at the offshore helideck, shortly after takeoff, the Helicopter entered into high rate of descent toward the sea and impacted the water approximately 600 meters northwest of the rig. Both pilots sustained fatal injuries, and the Helicopter was destroyed. There were no passengers on board.

The Investigation confirmed that the Helicopter was airworthy before the flight, with maintenance and inspection records current. The engines were found to be operating normally at the time of impact. The Helicopter was within weight and balance limits, and environmental conditions were within operational parameters.

Extensive examination of the recovered components was conducted with the both the Helicopter and engines manufacturers' support. The main rotor transmission and mast assembly were examined at Bell Textron laboratories, confirming no pre-existing fractures or mechanical defects. Evidence of grease splatter consistent with the approved Syn-Tech NS-3913-G1 lubricant was found, indicating normal lubrication of the main driveshaft coupling prior to impact. Both Pratt & Whitney PT6T-3B engines were examined at the manufacturer's facilities in Canada, revealing no anomalies that could have contributed to power loss. The SmartCycle data confirmed both engines were delivering high power and maintaining normal rotor speed up to the point of impact.

The Accident was categorized as controlled flight into terrain (CFIT) that was most probably caused by spatial disorientation due to limited external visual references during night operations, resulting in degrading the pilots' situational awareness and impairing their ability to maintain proper attitude and level-off maneuver. The degraded situational awareness disabled the pilots from preventing the high rate of descent, and taking timely and effective recovery actions.

The Air Accident Investigation Sector determines that the most probable contributing factor to the CFIT was degraded cockpit performance during a dark night flight, compounded by the cockpit crew composition, specifically, an Instructor who was not adequately rested under the applicable prescriptive scheme, and a Pilot Undergoing Route Familiarization to that location during night conditions for the first time.

Two safety recommendations were issued to Aerogulf Services to enhance the flight training and operational oversight system to ensure the effectiveness of risk controls associated with high-risk operations, such as night offshore flights, and review and strengthen its organizational controls and operational policies related to fatigue risk management and crew pairing in potential-risk helicopter operations.

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# 1. Factual Information

## 1.1 History of the Flight

On 7 September 2023, an Aerogulf Bell Textron Inc. Bell 212 Helicopter, registration marks A6-ALD, was conducting a non-revenue night training flight on an offshore helideck. The flight originated from Al Maktoum International Airport (OMDW), Dubai, the United Arab Emirates, and was planned to operate to the ARAS Driller Rig helideck, located offshore in Umm Al Quwain. The Helicopter was operated by two flight crewmembers, comprising an Instructor pilot (Instructor) occupying the left seat and a Pilot Undergoing Route Familiarization in the right seat. No passengers were on board the flight.

Both flight crewmembers had the rank of captain. The Pilot Undergoing Route Familiarization was designated as the pilot flying (PF), whereas the Instructor was the pilot monitoring (PM) and was handling the radio communications.

The planned training flight was performed in accordance with the Operator's approved flight operational procedures and represented the Pilot Undergoing Route Familiarization first night flight operation, on B212, to ARAS Rig. In accordance with the Operational Flight Plan (OFP), the flight was conducted under Visual Flight Rules (VFR) for the night flying exercise. The Operator informed the Investigation that the Instructor had planned to perform five training circuits, each including a takeoff and landing at the helideck, and this plan was communicated in advance to the Rig operator.

The load sheet indicated that the weight and balance was within the limits, with 1,600 lbs of fuel and a take-off weight of 9,342 lbs. The OFP indicated the fuel burn from OMDW to ARAS Rig was estimated at 393 lbs, and 417 lbs for the return flight to OMDW.

The Helicopter took off from runway 30 at OMDW, at about 1918 local time of the United Arab Emirates, and climbed to 1,100 feet pressure altitude. In accordance with the OFP route, the flight crew initially flew the Helicopter northwest after departing from OMDW for approximately 15 nautical miles before turning northeast off the coast of Palm Jebel Ali, Dubai, and continuing another 42 nautical miles towards the Rig. Figures 1 and 2 illustrate the flight path after departure from OMDW and the circuits flown at the Rig.

At 1930, the PM (the Instructor) communicated with the Rig radio operator and provided an estimated time of arrival at 1949. Furthermore, the PM informed that the Helicopter was operating at a height of 1,000 feet pressure altitude, with two pilots on board and 2 hours 30 minutes of fuel remaining. The radio operator acknowledged the message.


**Figure 1.** The Helicopter flight path from OMDW to ARAS Rig

In his second call at 1938, the PM informed the Rig radio operator that they were 12 minutes away from landing and requested the latest weather information.

The Rig radio operator passed on the weather conditions, reporting variable wind speeds of 7 to 9 knots from 60 degrees, visibility of 7 to 8 kilometers, and 1002 millibars air pressure. The ambient temperature was 32 degrees Celsius with calm seas.

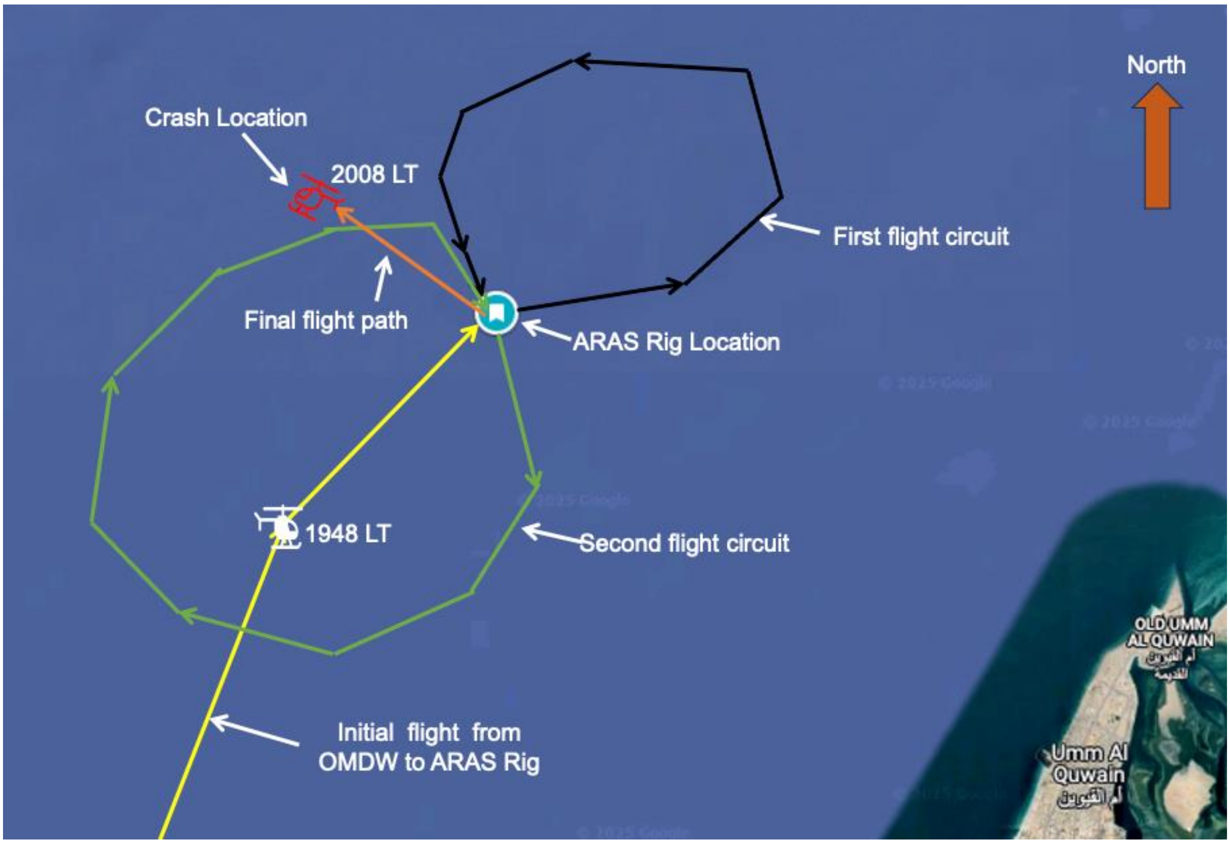


**Figure 2.** The Helicopter flight circuits and crash location

At 1948, the PM contacted the Rig radio operator, informing that the Helicopter was about two minutes away from landing. The Rig radio operator acknowledged the information and granted clearance to land at the helideck pad.

At 1950, the Helicopter successfully landed in a southeast direction at the Rig helideck.

The Helicopter took off at 1952 and performed a left circuit pattern as the flight crew commenced the first of the five circuits. Within three minutes, the Helicopter turned back and descended for the landing, heading southeast like the previous landing. At 1959, the Helicopter took off again, and the flight crew performed a right circuit pattern around the Rig, landing at 2004 on a southeast heading.

At about 2007, the Helicopter lifted off, hovered, and rotated almost 180 degrees to a northwest heading and continued the flight in this direction. About one minute later, at 2008, the Helideck Landing Officer (HLO) contacted the Rig radio operator reporting that the Helicopter had crashed into the sea approximately 600 meters of the Rig in the northwest direction. The HLO reported not seeing the Helicopter's attitude prior to the crash, but observed a surface fire after the impact. There was no reported distress transmission made by the flight crew.

At 2009, the Rig radio operator promptly notified the Operator's management and initiated a distress call for search and rescue. The Operator's *emergency response plan* was immediately activated, and the search and rescue team was deployed to the crash site.

Both flight crewmembers sustained fatal injuries. The body of the Pilot Undergoing Route Familiarization was recovered from the crash site within about 12 hours following the occurrence, whereas the body of the Instructor was recovered on the third day of the search operation. The wreckage recovery from the seabed extended over a period of five days, during which a portion of the helicopter wreckage was successfully recovered.

## 1.2 Injuries to Persons

Both pilots sustained fatal injuries.

## 1.3 Damage to the Helicopter

The Helicopter was destroyed due to the impact with the sea.

## 1.4 Other Damage

There was no other damage to property and/or the environment.

## 1.5 Personnel Information

### 1.5.1 Flight crew information

The qualification and experience of the flight crewmembers are shown in table 1.

**Table 1.** Flight crew information

| | Instructor (left seat) | Pilot Undergoing Route Familiarization (right seat) |
|---|---|---|
| Age | 57 | 52 |
| Type of licence | ATPL-H | ATPL-H |
| Valid to | 9 December 2025 | 22 October 2027 |
| Rating | Bell 212/B412/AW169 | Bell 212/B412 |
| Total flying time (hours) | 9,011.2 | 7,030.5 |
| Total Bell 212 hours | 299.1 | 492.8 |
| Bell 212 hours last 90 days | 24.3 | 7.8 |
| Bell 212 hours last 7 days | 4 | 3.2 |
| Bell 212 hours last 24 hours | 2 | 0 |
| Last proficiency check | 17 June 2023 | 31 January 2023 |
| Medical class / validity | Class 1 / 30 September 2023 | Class 1 / 16 February 2024 |
| English level proficiency | Level 5 | Level 5 |
| Medical limitation | VDL | VNL |

Both flight crewmembers possessed valid air transport pilot licenses for helicopters (ATPL-H) issued by the General Civil Aviation Authority of the United Arab Emirates (GCAA). Additionally, their instrument rating (IR) and class 1 medical certificates were valid.

The Instructor was approved by the Operator as a line training captain and was authorized to operate as a captain on both the Bell 212 and Bell 412 helicopters for day and night flights. He was diagnosed with vision limitation requiring correction for distant vision (VDL).

The Pilot Undergoing Route Familiarization was authorized by the Operator, as a captain, to fly the Bell 212 for day flights, and the Bell 412 for day and night flights. He was diagnosed with vision limitation requiring correction for near vision (VNL).

Both flight crewmembers joined the Operator in June 2022.

Since February 2023, both pilots completed six day-time flights together, accumulating a total of 16.8 flight hours on the Bell 212. The Instructor served as the pilot-in-command for five of these flights. Their last flight before the Accident flight, lasting 0.9 flight hours, took place on 6 April 2023, with the Instructor serving as the pilot-in-command. The night training flight on 7 September 2023 was their first night flight together, whereas their initial flight together took place five months earlier. As reported by the Operator, both pilots had a professional working relationship.

ARAS Rig was selected for the Pilot Undergoing Route Familiarization initial training flight due to the Operator's contract requirement with ARAS Rig operator, which included having night standby and medical evacuation (medevac) support. Thus, rostered pilots were required to have valid currency for night operations.

### 1.5.2 Flight crew experience and training

#### 1.5.2.1 The Instructor

According to the licensing records obtained from the GCAA, the Instructor had fulfilled the qualification requirements for the Bell 212 and Bell 412 type ratings, including IR and multi-pilot (MP) authorizations, on 22 August 2017, with an initial validity of one year. Subsequently, the Instructor's type rating and associated authorizations were revalidated annually by the GCAA-approved examiners, with the most recent exam conducted on 17 June 2023, valid until 30 June 2024. In addition, the Instructor had completed the Operator's recurrent crew resource management (CRM) training on 18 April 2023, in accordance with the Operator's approved training program.

Prior to joining the Operator, the employment history for Instructor indicates that he was qualified as a pilot and started to fly helicopters in 2006 with endorsements for the Robinson R22/R44, Bell 206/212/412, and Leonardo AW169. From September 2009 to May 2022, the Instructor was employed as a line training captain on Bell 412 and AW169 captain by a helicopter operator in the United Arab Emirates. He flew missions supporting both passenger and cargo transport, as well as operations within the offshore oil industry.

The Instructor joined the Operator in June 2022 as a captain. He practiced the role of offshore captain after completing the Operator's required training. On 7 November 2022, he was appointed as the Operator's flight safety officer and line training captain for Bell 212 on 25 April 2023, and for Bell 412 EP on 15 May 2023.

Starting 13 June 2023, the Instructor completed a GCAA-approved recurrent training program for the Bell 412 EP helicopter at GCAA-approved flight training facilities, which comprised two days of ground school followed by three days of full-flight simulator training and a check ride. The Operator stated that the recurrent training also included the Bell 212 helicopter, and the Instructor's most recent annual line check had been conducted on 12 February 2023. At the time, the Instructor was serving as the Operator's flight safety officer and had been issued a provisional approval by the General Civil Aviation Authority (GCAA) as a postholder crew training on 26 May 2023 for a validity period of three months, which was subsequently renewed on 7 August 2023 with validity up to 7 November 2023.

The Instructor pilot-in-command flying hours at the Operator was 45 flight hours, which comprised 15 hours on the Bell 412 and 30 hours on the Bell 212. His previous night currency training on the Bell 212 was on 27 July 2023 with an expiry on 24 October 2023.

At the Operator, as the pilot flying on Bell 212, the Instructor's night flight offshore experience consisted of 3.2 hours, which included eight takeoffs and landings from a helideck. As pilot monitoring, his offshore helideck experience on the Bell 212 included 5.4 night flight hours and nine takeoffs and landings. His Bell 212 night flying experience included five takeoffs and landings on ARAS Rig. The Instructor’s most recent experience as pilot flying was on 6 September 2023, and as a pilot monitoring on 27 July 2023.

On 6 September 2023, the Instructor conducted a night training flight, which departed from OMDW at 1848 and returned after approximately two hours of flight. This training flight included three landings at the ARAS Rig helideck before returning to OMDW.

The Instructor had attended a postholder course conducted during the period 5 to 7 September 2023. He was rostered for flight duties scheduled on the day of the Accident, following the completion of the final day of the course. On the day of the Accident (7 September 2023), the exact flight duty period, which would have extended from a time prior to the commencement of the course in the morning until the completion of the final planned training circuit, was not documented. The departure time of the Helicopter from OMDW was recorded at 1918.

#### 1.5.2.2 The Pilot Undergoing Route Familiarization

According to the records obtained from the GCAA, the Pilot Undergoing Route Familiarization had successfully completed the licence tests for the Bell 212/412 type rating, including IR and MP qualification, on 3 March 2022, with a validity period of one year.

Prior to joining the Operator, the employment history of the Pilot Undergoing Route Familiarization shows that he was qualified as a pilot and started to fly helicopters in 2009, with endorsements for the Bell 206/212/412. He flew missions to support offshore oil industry operations. From 2015 to 2022, the Pilot was employed as a captain on Bell 412 by a helicopter operator in the United Arab Emirates.

The Pilot joined the Operator in June 2022 as a day-time commander. At the Operator, he accumulated 213.5 flight hours including 31.7 hours on the Bell 412 and 181.8 hours on the Bell 212. On 27 February 2023, he successfully passed his pilot-in-command exams and was authorized as a captain by the Operator. The Pilot had 20.1 flight hours as pilot-in-command on the Bell 212.

Starting 23 January 2023, the Pilot successfully completed the GCAA-approved recurrent course for Bell 412 EP helicopter at the GCAA-approved flight training facilities. This included two days of ground school followed by three days of full-flight simulator training and check ride. The Operator stated that the recurrent training also included the Bell 212 helicopter. The last annual line check for the Pilot was on 27 February 2023.

The Pilot’s subsequent type rating revalidation was accomplished following the successful completion of the GCAA tests on 25 January 2023, with an expiry date of 31 January 2024. In addition, the Pilot had attended the Operator’s recurrent CRM training on 18 April 2023, conducted in accordance with the Operator’s approved training program.

The Pilot was not authorized to conduct night flights as pilot-in-command and pilot monitoring on the Bell 212. However, he was authorized to operate as both pilot-in-command and pilot monitoring for day operations on the Bell 212, including flights to offshore rigs helidecks, and helipads.

As part of his initial offshore night flight training, one year before the Accident flight, on 5 September 2022, as second-in-command, he executed three offshore circuits which included three takeoffs and landings from an offshore helideck. The line training captain's feedback was mainly satisfactory. The Operator stated that the continuation of this night flight training was suspended as the Pilot had to attend administrative work the following day related to his new position with the Operator. On 7 November 2022, the Pilot was appointed as the Chief Pilot, a position he held until the Accident.

The Pilot’s offshore night flight training resumed on the night of the Accident, which was his first flight to the ARAS Rig. Based on his schedule, this was the first of three consecutive-night duty, from 1800 to 0600, following a single day off lasted over 24 hours. On the Accident day (7 September 2023), the exact time his flight duty started prior to the Helicopter departure from OMDW at 1918 was not documented.

## 1.6 Helicopter Information

The Bell 212 is a two-bladed single main rotor, twin Pratt & Whitney PT6T-3B engine, medium helicopter that first flew in 1968. The Accident Helicopter, manufacturer serial number (MSN) 30809, was configured to carry two pilots and nine passengers. The Helicopter records showed that it was manufactured in 1976 and registered in the United Arab Emirates on 16 September 1986. The maximum take-off weight was 11,200 pounds (5,080.3 kilograms). Prior to the Accident, the total flight hours were 27,850.70, 31,591 cycles. The Helicopter was certified for visual flight rules (VFR) operations and category 1 instrument flight rules (IFR) operations under IFR day and night, in non-icing conditions. Figure 3 illustrates the Bell 212 dimensions.

Tracking of the Helicopter location was performed by SkyTrac®/ISAT which is an automatic system to track the position of Helicopter using the Iridium Satellite system.

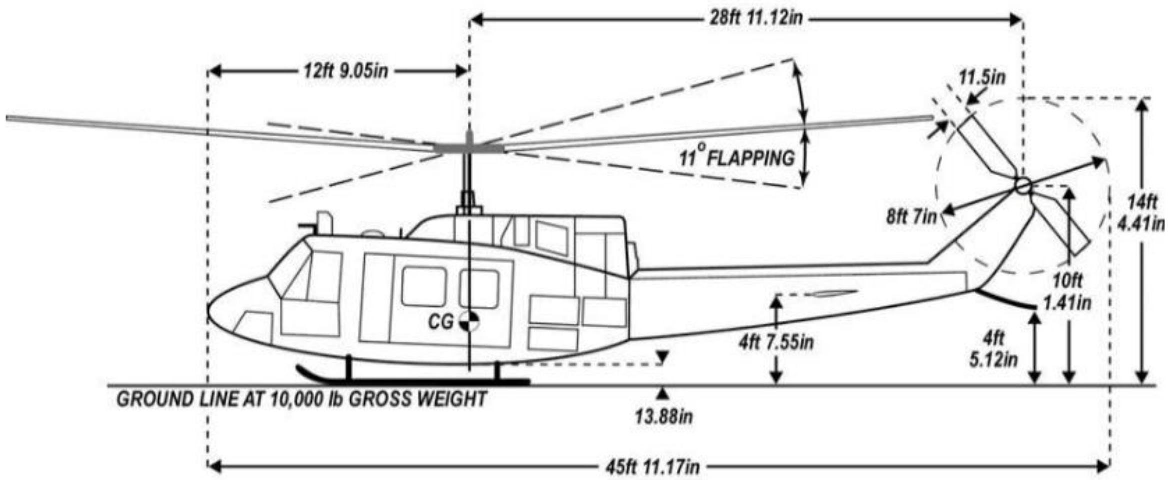


**Figure 3.** Bell 212 helicopter dimensions

### 1.6.1 Helicopter general data

Tables 2 illustrates the Helicopter data.

| **Table 2.** Helicopter data | |
|---|---|
| Manufacturer: | Bell Textron Inc |
| Model: | Bell 212 |
| MSN: | 30809 |
| Year of Manufacture | 1976 |
| Nationality and registration mark: | United Arab Emirates, A6-ALD |
| Name of the owner: | Aerogulf Services Co (LLC) |
| Name of the Operator: | Aerogulf Services Co (LLC) |
| Certificate of registration | |
| Number: | 04/86 |

| | | |
|---|---|---|
| Issuing Authority: | | GCAA |
| Issuance date: | | 16 September 1986. Reissued on 15 August 2000. |
| Certificate of Airworthiness | | |
| | Number: | AGS/09 |
| | Issuing Authority: | GCAA |
| | Issuance date: | 14th September 1987. Reissued on 02 May 2013 |
| | Valid to: | ARC issued on 2nd February 2022.<br>Expires on 1st February 2024. |
| Total hours since new (TSN) (hours): | | 27,850.70 |
| Total cycles since new (CSN): | | 31,591 |
| Last major inspection check, type, date and hours/cycles: | | 600 Hours/12 Months Inspection done on 19/06/2023 (27,846.2 hours and 31,574 cycles). |
| Total hours since last major inspection (TSI): | | 4.5 |
| Total cycles since last major inspection (CSI): | | 17 |
| Last inspection, type, date: | | PDC / 30 Day / 07 Days Insp / 7 September 2023 |
| Maximum allowable takeoff weight: (pounds) | | 11,200 lbs |
| zero fuel weight: (pounds) | | 7,742 lbs |
| Fuel | | 1,600 lbs |
| Take-off weight | | 9,342 lbs |

### 1.6.2 Helicopter engines' data

Table 3 illustrate the engines' data.

**Table 3.** Engines' data

| | | |
|---|---|---|
| Engine manufacturer | Pratt & Whitney Canada | |
| | No.1 engine | No.2 engine |
| Model | PT6T-3B | PT6T-3B |
| Engine Serial Number | 63621 | TB0117 |
| Date installed | 6 February 2023 | 7 September 2020 |
| TSN (hours) | 9,439.9 | 10,797.6 |
| CSN | 30,345 | 45,152 |
| TSI (hours) | 76.7 | 814.9 |
| CSI | 149 | 1426 |

### 1.6.3 Helicopter Maintenance records

The Helicopter was maintained in accordance with the GCAA-approved maintenance schedule and was certified as airworthy for the flight on 7 September 2023. There were no deferred defects noted on the last Helicopter maintenance log page.

On 9 August 2023, the Helicopter main driveshaft was replaced due to the time limit of 600 flight hours/12 months re-greasing inspection in accordance with the Bell 212 maintenance program. As part of the task, the driveshaft dynamic balancing was carried out with a final reading of 0.2 and 0.25 inch per second (IPS). The installed part information is as follows:

- Part number: 212-040-005-103
- Serial number: A20-02420
- Time since new: 19,765.70 hours
- Time since overhaul (TSO): 2,474.40 hours
- Life remaining: 525.60 hours.

After the main drive shaft replacement, the Helicopter operated two flights before the Accident flight. The Helicopter flew for 0.7 flight hours and completed nine cycles on 13 August 2023, and the last flight took place on 6 September 2023, lasting for 2 flight hours and 4 cycles.

As part of the continued airworthiness, the Bell 212 maintenance program required that the engine to transmission main driveshaft and coupling be regularly inspected for corrosion, condition, security, overheat, couplings for grease leakage at the following intervals:

- Pre-flight check
- After last flight (ALF) check
- 25 hours/30 days inspection
- 100 hours/90 days inspection
- 600 Hours/12 Months regreasing

Prior to the Accident flight, a pre-flight check and a 30-Days inspection was performed and certified in the maintenance logbook. No findings were recorded.

The tail rotor hub assembly fitted to the Helicopter information is as follows:

- Part number: 212-010-701-139
- Serial number AG76
- Life remaining:  185.10 hours
- Installed date: 2 September 2019

### 1.6.4 Flight control and indication systems

Instrumentation for the Bell 212 is normally equipped for visual and instrument flight rules. Engine and transmission instruments and the caution panel are grouped in the center section of the panel for easy observation from either seat. Flight and navigation instruments are grouped on the right side of the panel in front of the pilot. Additional instruments are installed in the left side of the instrument panel for two pilot operations. The instruments have complete white lighting.

The Helicopter was fitted with an automatic flight control system (AFCS) to provide increased stability and reduced pilot workload in the pitch, roll, and yaw axes. Selected AFCS mode operation annunciates on the cockpit instrument panel by a three-segment light (PITCH, ROLL, YAW). The AFCS functions in two modes: automatic with turn and trim functions; and pilot cyclic steering. The AFCS annunciation is applicable to both modes.

Attitude indicators display flight attitude relative to earth. Pilot and commander attitude indicators utilize data from respective three-axis reference sensor and rate-of-turn gyro. In addition, three-axis reference sensors furnish compass heading data to horizontal situation indicators (HSIs) and very high frequency (VHF) omni-directional range/localizer (VOR/LOC) navigation sets and commander three-axis reference sensor is utilized in conjunction with the

AFCS. The AFCS is checked for correct operations during the flight crew pre-flight checks in accordance with the *rotorcraft flight manual (RFM)*.

Pilot and commander rate-of-turn gyros provide data to rate-of-turn pointers which, together with inclinometers, function as turn-and-slip portions of respective indicators.

The Bell 212 caution and warning system provides the pilots with immediate notification of all major system malfunctions. Most of the caution and warning lights are located on the caution panel. Additional caution and warning lights are located on the instrument panels and readily visible to both pilots. Two 'MASTER CAUTION' lights alert the pilots if a malfunction occurs. Warning lights, which identify system malfunctions requiring the pilots' immediate attention, have black letters on a red background. Caution lights associated with systems that require other than immediate attention have amber letters on a black background.

The Helicopter flight controls were mechanical linkage systems, actuated by conventional helicopter controls, and are used to control flight attitude and direction. A "sync" elevator (horizontal stabilizer) is linked into the fore-aft cyclic control system. An electronically operated force trim, connected to cyclic and tail rotor controls, induce artificial control feel and stabilize the control stick and pedals to prevent them from moving of their own without any pilot input.

Cockpit flight controls are connected to push-pull rods, bell cranks, AFCS actuators, and hydraulic servo actuators which transmit pilot control movements directly to the rotor systems.

A review of subsequent flight records and pilot reports indicated that no defects or discrepancies were reported in relation to the AFCS or the flight director systems following the replacement.

### 1.6.5 Main driveshaft

The main driveshaft is installed between an adapter on the engine combining (reduction) gearbox and input drive quill on the transmission. The driveshaft is a steel tube with grease lubricated, spherical, splined coupling assemblies on either end to provide flexibility. After driveshaft replacement and to maintain vibration within safe operating limits, the driveshaft is balanced in accordance with the *BHT-212-MM-2 18-39* using Smiths Aerospace Rotor Analysis and Diagnostic System, Model AT (RADS AT). The balancing limit stated in the *maintenance manual 18-42,* paragraph 11 under the heading *'NOTE'*, stated:

> "The RADS AT is operating on present limits of 0.20 IPS for main driveshaft balance. If the operator desires to reduce the level to below 0.20 IPS then this can be done by pressing DO from limits screen. The RADS AT will specify adjustments required to achieve a O IPS balance."

The Bell 212 *maintenance manual* troubleshooting stated that a probable cause of grease leakage from the main driveshaft is "Improperly assembled driveshaft coupling" or "faulty packings or seals*.*" Corrective action includes, *"*Remove leaking coupling, disassemble, inspect, assemble, and install coupling…" or "Replace leaking packing (s) or seal (s)…" Figure 4 illustrates the location of the main driveshaft.

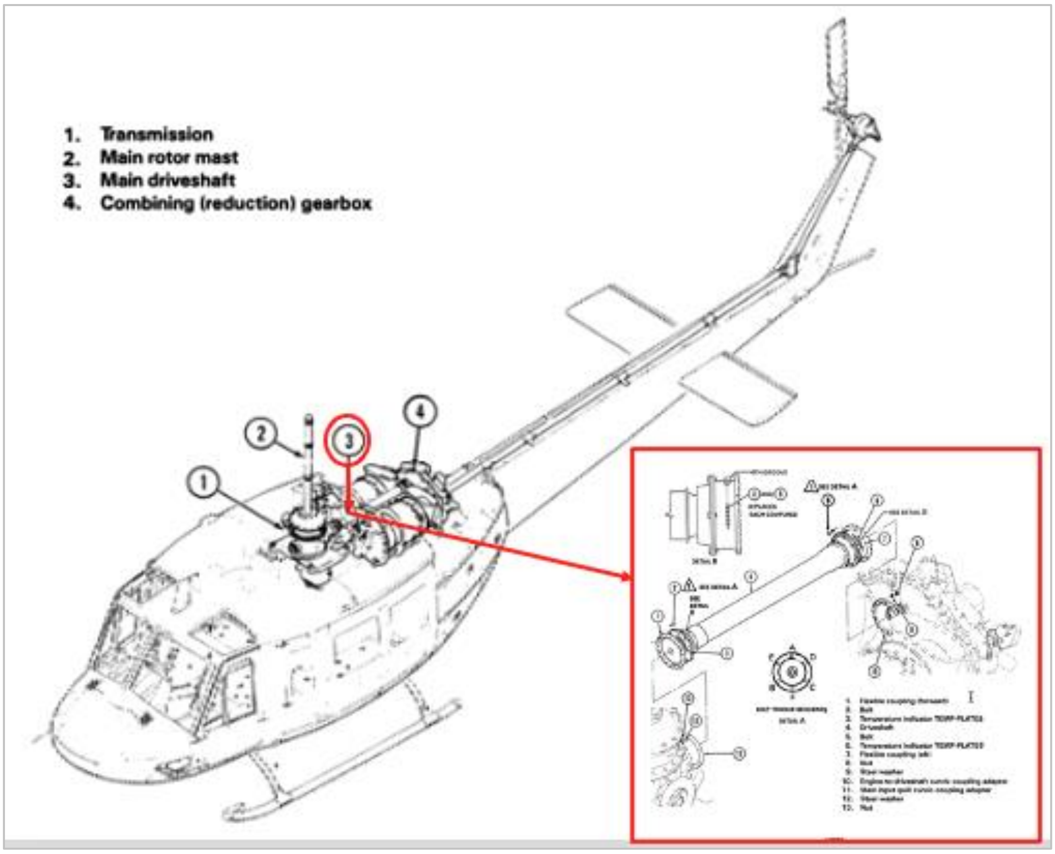


**Figure 4.** Bell 212 main driveshaft location

## 1.6.6 Helicopter limitations

The limitations are outlined in both the Operator's *operation manual – part B* (*OM-B*) and the Bell 212 *rotorcraft flight manual* (*RFM*). The *RFM*, Section 1 – *Limitations,* stated:

> "- minimum airspeed (Vmin) for IFR was 40 knots indicated airspeed (KIAS). Pilots are cautioned that due to control authorities required for flight at airspeed below 40 KIAS, the helicopter auto flight control system (AFCS) attitude (ATTD) mode should not be utilized except for ground checks.
>
> - never exceed speed (Vne) for IFR and VFR is 120 KIAS from sea level up to and including 3,000 feet density altitude (Hd) at 8,800 pounds gross weight (GW) or less GW decreasing linearly to Vne of 100 KIAS at 11,200 pounds.
>
> - Intentional manoeuvring resulting in roll attitudes in excess of 50° angle of bank, or pitch attitudes lower than 15° nose down or higher than 30° nose up are prohibited.
>
> - Perform takeoff with no more than 15% torque above hover power while accelerating to Takeoff Climb Out Speed (VTOCS). Refer to Section 4 for VTOCS."

The *Limitations* outlined: Autorotation speed – Normal: 70 KIAS; Max. Range: 90 KIAS.

## 1.7 Meteorological Information

Sunset for Umm Al Quwain on 7 September 2023 was at 1831. Nautical twilight was at 1921, and astronomical twilight was at 1948.

The moon was in its Last Quarter phase. This phase occurred on 6 September 2023, at 2221 UTC, which corresponds to 7 September 2023, at 02:21 local time. During the Last

Quarter phase, the moon appears half-illuminated, with the left half visible in the northern hemisphere[1]. The ambient natural light over the sea would have been at its minimum, creating total darkness (less than 0.1 lux[2]), aside from starlight and any distant light pollution.

Prior to the first landing of the Helicopter, the Rig radio operator reported that at ARAS Rig, there was a variable windspeed ranging from 7 to 9 knots at 60 degrees with visibility between 7 to 8 kilometers, and 1002 millibar air pressure. The ambient temperature was 32 degrees Celsius. As per the Operator's *operational flight plan*, the estimated time of arrival at ARAS Rig was at 1928, and the wind information given was 10 knots at 270 degrees.

## 1.8 Aids to Navigation

There were no navigational aids in the vicinity of the ARAS Rig.

## 1.9 Communications

The Investigation was informed that no audio communication or video recordings existed between the flight crew, and ARAS Rig radio operator. The information contained in this Report, regarding the communication between the Instructor (as the PM) and the Rig radio operator, were provided by the Rig radio operator during the Investigation interview.

The communications between the Instructor and Dubai air traffic control were made available to the Investigation and did not indicate any issues. No 'Mayday' call from the flight crew was recorded in the ATC communications.

## 1.10 Aerodrome Information

The ARAS Jack-up Driller Rig helideck was approved by the GCAA for helicopter takeoffs and landings. The Rig, as illustrated in figure 5, was managed by an oilfield drilling company and was located offshore in the Arabian Gulf Sea, approximately 12 nautical miles off the coast of Umm Al Quwain. The Rig and helideck pad were equipped with sufficient external lighting and a windsock, making them visible to the flight crew. The windsock on the Rig was visible from the landing deck. The helideck was approximately 165 to 175 feet above sea level.

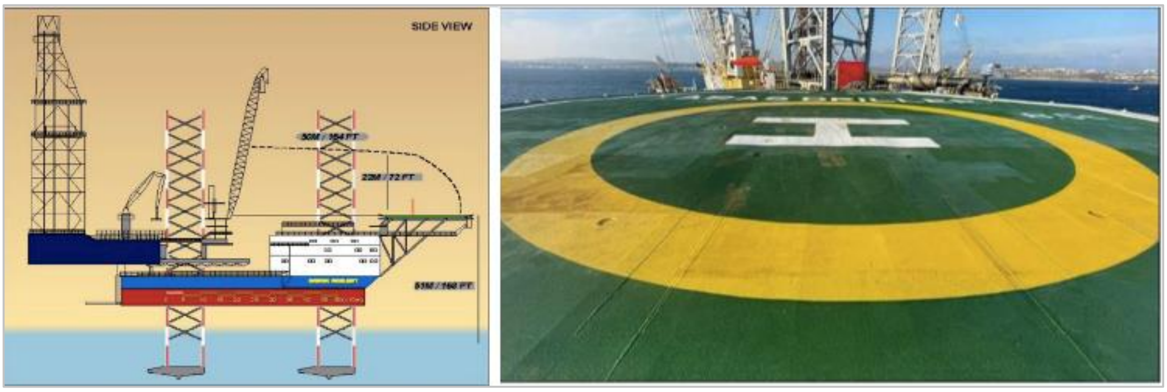


**Figure 5.** ARAS Driller Jack-up Rig and helideck

During July 2023, the Operator conducted a safety risk assessment before commencing the short-term contracted flights and medivac support for ARAS Rig. In addition to *Appendix B* of the *operations manual – part A (OM-A) – Helicopter Offshore Operations (HOFO)*, the Operator published *standard operating procedures (SOP) – Flight Operations,*

[1] LUNAF MOON website: https://lunaf.com

[2] Lux is about how bright a surface is illuminated. A reading of 0.1 lux means the surface is illuminated by an extremely low level of light, often representing near-total natural darkness. It is a level where the human eye can typically still function but is well below what is needed for any detailed or routine task.

*Vol 5, OPS -09*, which provided general operating procedures to be followed at the ARAS Rig. The *SOP* did not contain any subject matter related to helicopter training flights conducted at the Rig.

## 1.11 Flight Recorders

The Helicopter was not equipped with a flight data recorder (FDR) or cockpit voice recorder (CVR), and it was not required to be equipped with these recorders according to FDR/CVR relevant provisions in the GCAA *CAR-AIR OPS CAT.IDE.H.* Thus, the Investigation was unable to determine the AFCS autopilot mode used by the flight crew during the flight circuits.

### 1.11.1 SmartCycle recorder

The Helicopter was equipped with a Pratt & Whitney SmartCycle recorder which is used for engine health monitoring. The main function of this recorder is to record the status of critical engine systems and components on helicopters so that early detection of progressive defects, or indications of them, is possible and rectification can be achieved before the defects impact operational safety.

The following parameters are recorded:

- N1 (RPM in %)
- N2 (Power turbine RPM in %)
- NR (main rotor rotational speed in %)
- Engine Torque in %
- ITT (Interstage turbine temperature in degree Celsius)
- Airspeed in knots
- Altitude (pressure altitude in feet)
- Combined torque which is a calculated figure.

The SmartCycle electronic unit was found amongst the wreckage and the stowed data in the built-in memory was successfully downloaded by the manufacturer, including the Accident flight data.

### 1.11.2 SmartCycle flight data

For the data of the Accident flight, figure 6 illustrates the departure of the Helicopter from OMDW, showing altitude, and airspeed during the three landings and takeoffs at ARAS Rig, until the flight data was lost due to the Helicopter’s impact with the sea.

The recorded data indicates that the Helicopter's first landing at the Rig occurred at approximately 1950, and it departed at 1952, steadily climbing for two minutes to reach a pressure altitude of 1,120 feet, while attaining a maximum airspeed of 95 knots. The second landing took place at 1957, followed by departure one minute later. The Helicopter then climbed to 1,150 feet in two minutes, reaching a maximum airspeed of about 102 knots. The third landing on the helideck occurred at approximately 2004.

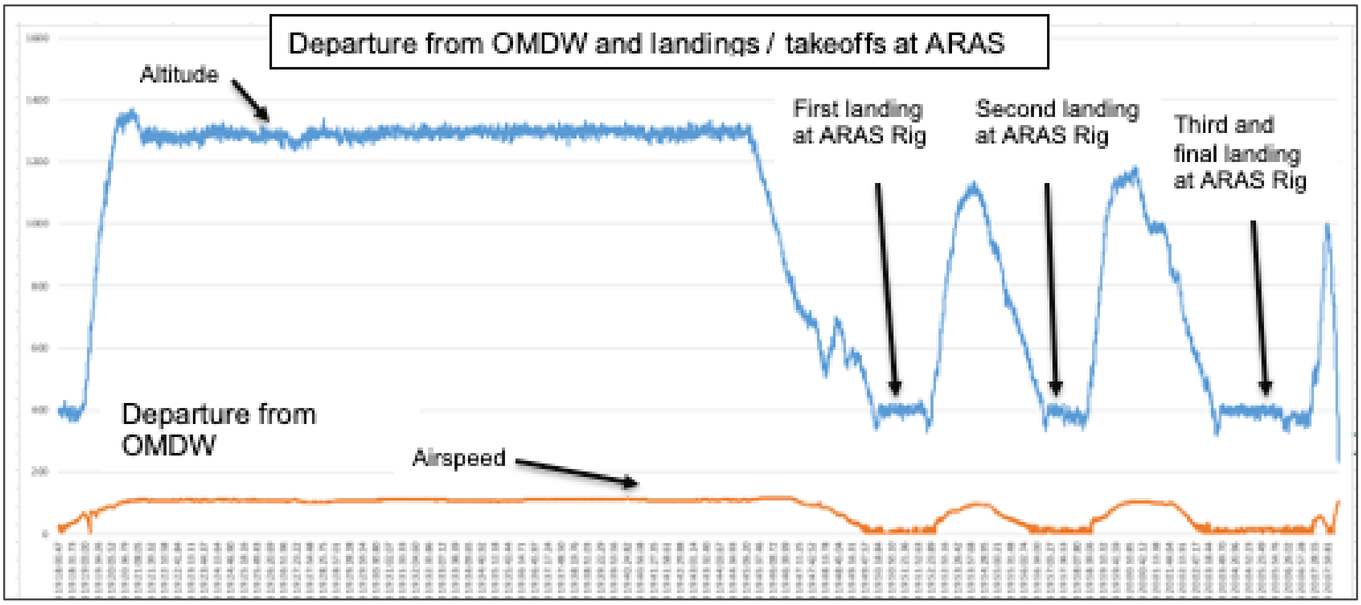


**Figure 6.** SmartCycle data – Helicopter flight from OMDW to ARAS Rig

Appendix A of this Final Report illustrates the Helicopter's final departure until the impact.

At 2007:20, the Helicopter departed the Rig and started ascending. At 2007:45, the SmartCycle data recorded that the Helicopter reached a maximum airspeed of 60 knots at a pressure altitude of 680 feet while continuing its climb. The maximum altitude reached was 1,000 feet pressure altitude at 2008:00.

Thereafter, the recorded data shows that the airspeed decreased to between 0 and 20 KIAS, and a high rate of descent was established. Further, the recorded data indicates that this condition prevailed for a period of about 14 seconds reaching an altitude of 750 feet.

Immediately after 2008:14, the airspeed rapidly and continuously increased, reaching 105 knots just before impact with the sea at approximately 2008:27.

During the final climb from the Rig, at an altitude of approximately 500 feet, the calculated combined torque gradually decreased from 83% to 52%, as the Helicopter reached 1,000 feet. Soon after, the Helicopter started to descend, and the combined torque started to increase and reached 72% as the Helicopter was descending below 600 feet pressure altitude. The combined torque then started to decrease and reached 60% just before impact.

The final flight recorded data shows that during the Helicopter climb and the descent until impact, the rotor speed maintained a reading close to 100%, and both engines N1 speed and interstage turbine temperature (ITT) did not indicate any significant changes. Both engines indicated that they were running normally until impact.

## 1.12 Wreckage and Impact Information

After the impact with the salt sea water, most of the Helicopter submerged to the bottom of the sea to a depth of approximately 36 meters. The sea depth and strong undercurrents significantly impacted the recovery of the Helicopter wreckage.

The wreckage recovery was accomplished by the Ministry of Defense and transported to a storage area at OMDW. The Investigation team, along with the accredited representatives and technical advisers examined the wreckage at this storage area.

Throughout the 5-day recovery operation, major wreckage was recovered on the third and fourth days. Parts of the Helicopter were scattered in a radius of about 1 kilometre. Figure 7 illustrates the major components that were not recovered, highlighted in green.

Several parts were affected by the salt water and showed advanced stage of corrosion, particularly those made of magnesium. As a result, the accessory gearboxes of both power sections were mostly dissolved, along with the reduction gearbox.

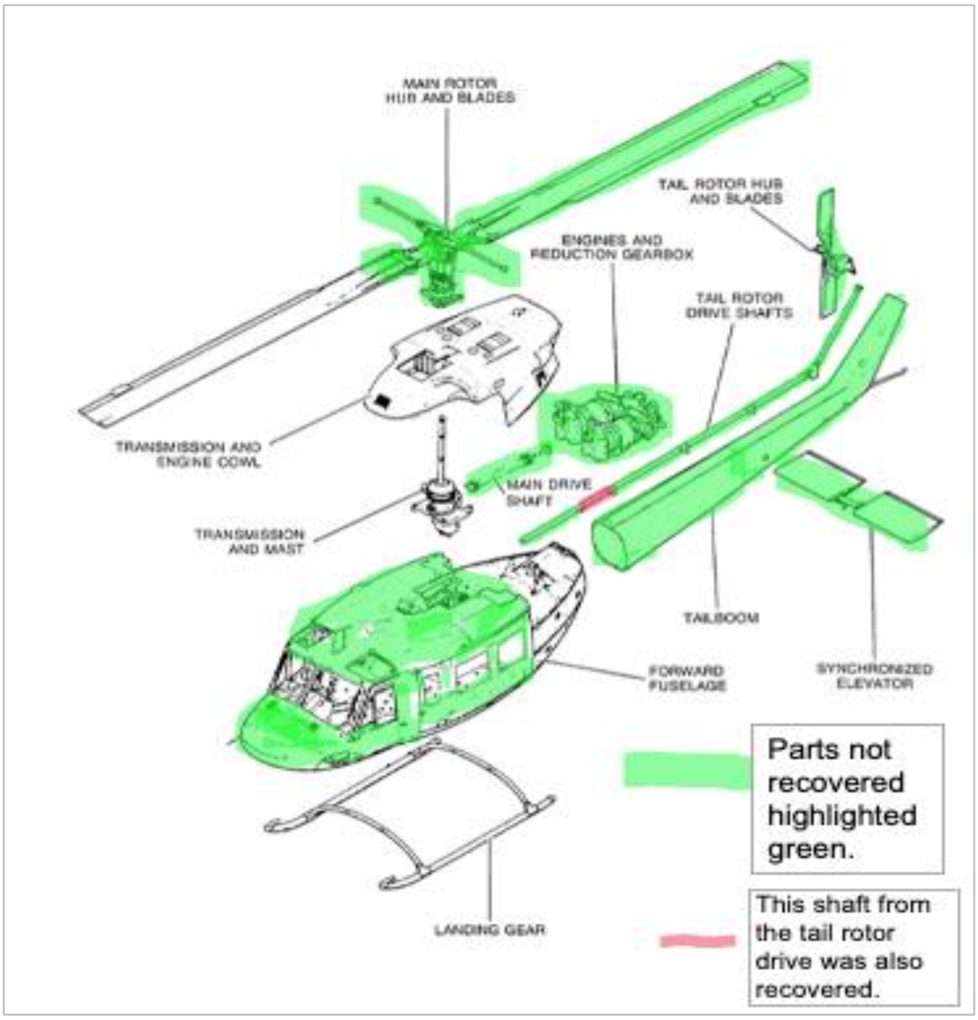


**Figure 7.** Bell 212 major structure and components not recovered highlighted in green

The major components of the Helicopter that were recovered and examined included the instrument panel, lower fuselage deck, both engines and their surrounding structures, the remaining rotor mast, swashplates and supports, transmission cases with the accessory drive and sump case, dual servo and anti-torque servo actuators, fragments of a main rotor blade identified as parts of a single blade, as well as deployed rafts and other float system components.

The following are significant Helicopter parts that were not recovered from the wreckage:

- Flight control system to include all pedals and the synchronized elevator;
- The tail boom;

- Tail rotor assemblies, including four of the five tail rotor driveshafts, intermediate and tail rotor gearboxes, and all tail rotor components;
- The main rotor hub and stabilization bar assemblies;
- Both main rotor blade roots and the entire main rotor blade assembly;
- The main driveshaft;
- The pedals;
- The upper cockpit and the upper fuselage extending to the end of the cabin; and
- Both pilot seats.

The recovered parts from the tail rotor drive system included the aft short shaft, still attached to the transmission drive, and the detached adjacent drive shaft. This single shaft had part number: 204-040-620-009 and serial number: A-FS14408.

Based on the observations exhibited by the recovered fuselage, the Helicopter experienced substantial compression forces upon impact with the seawater. All fractures observed were assessed as due to overload forces from impact. The upper cockpit and upper fuselage to the end of the cabin were separated from the floor structure, with both pilot seats breaking away at their mounting points. No survivable cabin space was evident from the wreckage recovered.

All recovered pylon mounts indicated signs of fracture due to overload and had separated from the fuselage. The recovered transmission cases and remaining rotor mast remained as a single unit. The rotor mast sustained an overload fracture, and the entire upper main rotors, along with the less fractured parts of a single main rotor blade, were not recovered. The recovered blade was fragmented into several pieces, accounting for approximately 60-70% of a single main rotor blade, excluding the blade grip and doubler section of root.

The rotor brake handle suffered an overload fracture at the base, and the handle was not found among the recovered wreckage. The Center console was heavily damaged, providing little useful information for the examination. Both collective levers were present and remained attached to the fuselage floor. Throttle control positions could not be determined. The right-side cyclic fractured in overload at the grip, while the left-seat cyclic was not among the recovered wreckage with an overload fracture observed at its base.

The right and left hydraulic cyclic actuators remained attached, whereas the upper collective actuator was fractured due to overload. The collective actuator remained attached to the part of the fuselage that was still attached to the skid landing gear crossbar. A single hydraulic fluid reservoir was available and examined, and upon opening, it was found to contain a residue of hydraulic fluid with a normal appearance and no visible contamination.

The skid landing gear components detached from the fuselage. All sections were fractured at multiple points away from fuselage, along with other landing gear components, as a result of overload.

Almost the entire cockpit instrument panel was recovered as a single, intact unit. Most of the gauges were found with shattered glass faces and several missing needles. It was noted that both the left and right vertical speed indicators were pegged at a high rate of descent, exceeding 2,000 feet per minute (FPM). No other meaningful data could be interpreted from the condition of the cockpit instruments. Overhead circuit breaker and switches panel was recovered but nothing significant could be interpreted.

Both engine fuel shutoff valves appeared to be in the open position. The engine fire warning and both extinguishing T-Handles were found in their normal positions, and neither of the fire bottle pressure discharge indicators had been activated.

Figure 8 illustrates the left and right vertical speed indicators (VSI) and the engine fire T-handles.

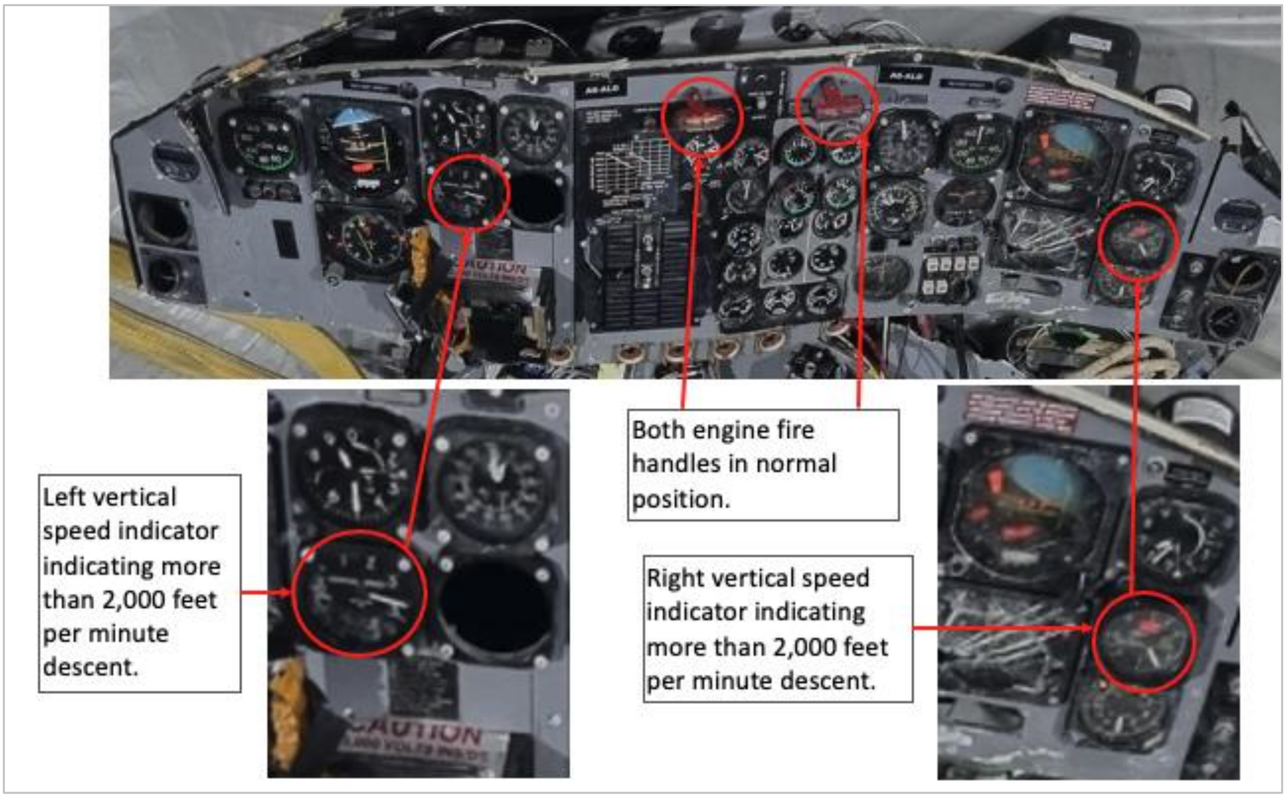


**Figure 8.** Helicopter vertical speed indicators showing in excess of 2,000 FPM

## 1.13 Medical and Pathological Information

Post-Accident blood tests did not reveal psychoactive materials that could have impaired the flight crewmembers' performance.

## 1.14 Fire

There were no signs of fire that affected the fatal crewmembers and the wreckage.

## 1.15 Survival Aspects

The Operator immediately activated the *emergency response plan* after the Accident and notifications were sent out accordingly. Within 10 minutes, a recovery team from ARAS Rig was deployed to the area of the Accident site. After one hour, the search and rescue operation commenced after the arrival of the search and rescue team along with the Coast Guard. The submerged Helicopter was estimated to be about 36 meters below the sea surface which created a challenge for the divers, especially as the exact location was unknown during the night-time operations.

No recovery of the flight crewmembers was made during the first night. On the next day, the body of the Pilot Undergoing Route Familiarization was found floating. On the third day, the body of the Instructor was found in the submerged wreckage. The divers reported that the Instructor was still strapped to his cockpit seat.

Due to the significant damages, the Investigation was unable to determine if the Helicopter emergency float system (EFS) was activated prior to the impact. Under controlled ditching, the externally mounted floatation device is designed to inflate automatically upon ditching by means of water sensors (two of the four sensors must be activated for flotation inflation) and to keep the helicopter floating upright. Alternatively, the system can be activated by either pilot using a guarded FLOAT pushbutton on the collective hand grip.

Based on the evidence from the retrieved Helicopter wreckage, the significant impact forces on the cockpit structure exceeded the Helicopter's crashworthiness design requirements, making survival unfeasible.

## 1.16 Tests and Research

The Investigation encompassed the visual examination of the Helicopter's both engines: No.1 engine serial number (ESN) 63621 and No.2 (ESN) TB0117; the accessory gearboxes; and the recovered engine components.

### 1.16.1 Bell Engineering examination – main rotor transmission/mast assembly

The main rotor transmission and mast assembly were sent to Bell Engineering Laboratories for detailed examinations.

The main rotor transmission and mast assembly fitted to the Helicopter information were as follow:

- Part number: 212-540-002-103
- Serial number: A-1096
- Total time since installed (TSI): 27,850.70 hours.

It was concluded that there was no fracture to the internal gearbox components, however, the support case, swashplate support lugs, and airframe components showed overload fractures attributed to the impact or the recovery efforts. Both transmission chip detectors were visually inspected, and no metallic chips were observed. All the planet gears, ring gears, sun gears, and spiral bevel gears in the transmission were all intact with no fractured teeth.

The main rotor transmission was retrieved and confirmed to have functioned properly before the impact, however, the advanced level of corrosion and contamination prevented any testing of the other accessories.

The external surface rear face (looking forward) of the main rotor transmission assembly showed evidence of splattered grease (figure 9). Analysis of the grease by Fourier-Transform Infrared Spectroscopy (FTIR) determined the material to be chemically similar to SYN Tech NS-3913-G1, which was the required driveshaft coupling grease. The main driveshaft female coupling spline teeth were all intact. The Operator confirmed that the grease used during maintenance to lubricate the main driveshaft coupling was Syn-Tech NS-3913-G1.

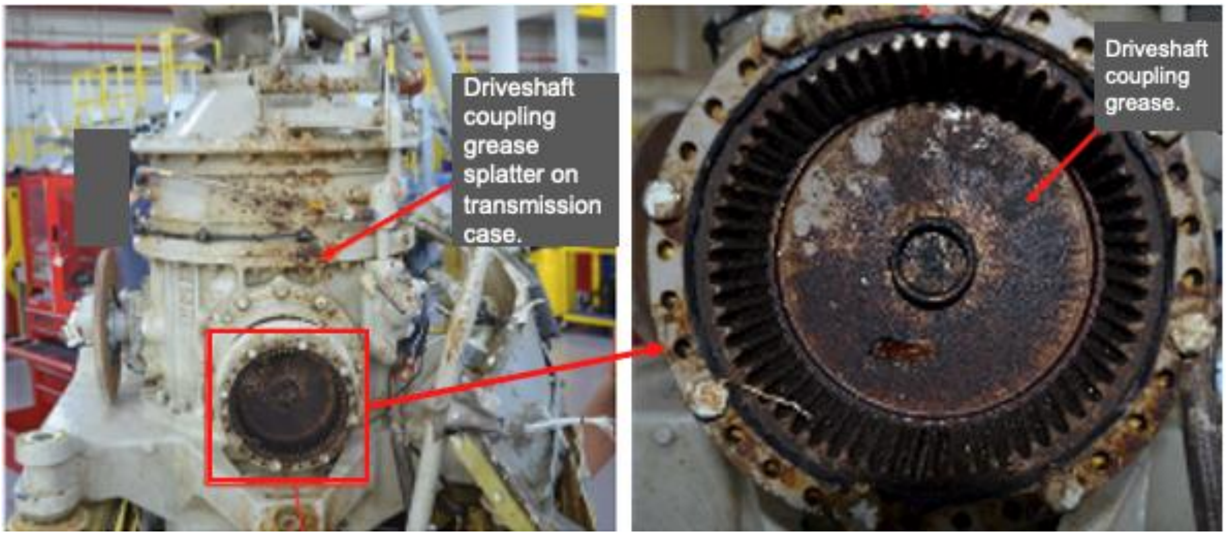


**Figure 9.** Main transmission case showing the grease splatter

### 1.16.2 Pratt & Whitney PT6T-3B engines, accessories, and data examination

Both engines were sent to Pratt & Whitney in Montreal, Canada, for detailed examinations.

The following is a summary of the Pratt & Whitney examination findings:

- As a result of both engines and accessory gearboxes being exposed to saltwater contamination for an extended period lasting more than five days, all components, particularly those made from magnesium, exhibited evidence of advanced corrosion.
- The visual examination and disassembly showed, mostly, impact damage, contamination, and corrosion.
- There were no defects or damage evidence that would have prevented normal operation prior to the Accident.
- No.1 ESN 63621 was received with the accessory gearbox missing due to advanced corrosion. The examination revealed the following:
  - Most of the accessories were not included with the power section, however, those received were investigated with no findings which could explain a problem in flight.
  - The exhaust case showed evidence of thermal cracking and deformation due to impact, suggesting the power section hit the water with force and was hot at the time.
  - There was evidence of rotational contact on the centrifugal impeller with the shroud.
  - The power turbine (PT) blades had rubbed on the PT shroud resulting in enough damage to cause four blades to release. The blades broke due to tensile overload, however there was too much damage (smeared material and environmental contamination) to confirm the crack initiation method.
- No.2 ESN TB0117 was received with the accessory gearbox missing due to advanced corrosion. The examination revealed the following:
  - Most of the accessories were not included with the power section, however, those received were examined with no findings.

- The exhaust case showed evidence of thermal cracking and deformation due to impact suggesting the power section hit the water with force and was hot at the time.
- There was evidence of rotational contact on the centrifugal impeller with the shroud. Additionally, the PT blades rubbed on the PT shroud. There were rotation signatures of the PT disc on the upstream stator.
- There was no damage to the compressor turbine blades.
- The combustion chamber was in a normal operating condition (with environmental contamination) and showed no evidence of unusual or suboptimal burn pattern. Though the inlet screen was deformed, there was no evidence of any pre-Accident damage.
- There was no damage to the compressor section, other than the impeller rubbing on the impeller shroud.

- The examination included the visual check and partial disassembly of the No.2 engine automatic fuel control unit (AFCU), manual fuel control unit (MFCU), fuel pump, compressor bleed valve (BOV) and fuel nozzles, as well as of No. 1 engine BOV and fuel nozzles, both engine Nf governors and the torque control unit (TCU). No. 1 engine AFCU, MFCU and fuel pump were missing. The examination revealed the following:
  - The advanced level of corrosion and contamination prevented testing of any of these accessories. The visual examination and disassembly showed mostly impact damage, contamination, and corrosion.
  - There were no defects or damage evident that would have prevented normal operation prior to the Accident.
- The Pratt & Whitney SmartCycle engine health monitoring recorded data shows that the Helicopter increased in altitude from the Rig, then slowed to a hover before accelerating with a decreasing altitude towards the ocean sea. The examination revealed the following:
  - The data analysis showed that the engines were both running and were coupled to the main rotor.
  - Both power sections were at high power as seen on NG, torque and temperature.
  - The Helicopter's main rotor (and both engines Np) was at approximately 100% throughout the recordings.
  - In the final half second, there was a sudden temperature increase on No.1 engine of 100 degrees Celsius. This sudden increase is believed to be either at the time of impact or just post-impact as the altitude had increased slightly on this final point.
- It was reported by eyewitnesses that before the helicopter started its final decent, there was flames from the exhaust. The engines examination did not exhibit physical evidence of this and the data showed both power section temperatures very stable prior to the decent with no evidence of a higher engine temperature.

The engine manufacture concluded that, *"Based on the physical evidence observed during the engines' investigation, both power sections were found to have been rotating at the time of impact. The SmartCycle box data that was provided, showed both power sections were at high power at the time of impact.'*

### 1.16.3 Flight simulation

In coordination with two helicopter captains designated as subject matter experts, a flight simulation was carried out by the Investigation as an attempt to replicate the Accident flight, using a level D flight simulation training device (FSTD) of Bell412 approved by the GCAA.

The aim of the session was to test hypotheses that may be relevant to the Accident causal and contributing factors. The FSTD conditions were set as closely as possible to the conditions on the night of the Accident, and the offshore Rig takeoffs and landings were recreated as accurately as possible.

However, the FSTD exhibited limitations and lacked complete fidelity to the Helicopter limitation, such that the Investigation was not able to replicate the Accident flight, and accordingly disregarded the observations on the Helicopter's performance.

## 1.17 Organizational and Management Information

### 1.17.1 The Helicopter Operator

The Operator was established in 1976 and subsequently obtained an *Air operator certificate* (*AOC*) issued by the GCAA under trade name Aerogulf Services hCo. (L.L.C).

The *operations specification* was to perform commercial air operations in accordance with the *Civil Aviation Regulations, CAR Part-3.* Besides providing commercial air operations, the Operator facilitated the oil and gas business activities of Dubai Petroleum in the emirate of Dubai. Additional operations included services of aerial work, medical emergency, cargo transportation, and filming.

The Operator's base was at Al Maktoum International Airport (OMDW). The fleet comprised Leonardo AW139, Bell 212, and Bell 206 helicopters. The Operator was approved by the GCAA as a *CAR-145* maintenance organization to perform all maintenance on its fleet of helicopters. On the date of the Accident, the Operator employed 17 helicopter pilots.

In accordance with the Operator's *SOP – Flight Operations, Vol 5 – OPS-09*, the flight routing from OMDW to ARAS Rig, stated:

> "Departures from DWC - Al Maktoum International to the ARAS Driller will follow ATC instructions. Standard departure routes are to be via JAFZA Intersection (or direct to where so cleared by ATC) – AP3-RIG.
> 5 NM to the ARAS DRILLER Decent to 500ft to be clear of OMR 83. After takeoff from the ARAS driller maintain 500ft till 5NM then climb to 1000 ft (or as instructed by ATC)."

The routing was reflected in the *operational flight plan* (*OFP*) that was issued on 7 September 2023. The *OFP* included reference to the training.

In accordance with the *OM-A*, Chapter 4.4 – *Operation on More than One Type*, pilots were allowed to fly more than one type or variant as stated, "…a Company flight crewmember shall not operate more than one type or a variant unless is competent to do so and in accordance with this Chapter."

Both the Instructor and the Pilot Undergoing Route Familiarization held management positions within the Operator and were allowed to pilot a helicopter as stated in *OM-A,* Section 7.1.4 – *Management Pilots,* which stated:

> "Any flying commitments by the management pilots shall be arranged so that they can discharge their ground staff management responsibilities, and still be able to comply with flight and duty time limitations and rest requirements.
>
> Management pilots are:

a. Director of Flight Operations.

b. Director of Training.

c. Chief Pilot; and

d. Flight Safety Officer."

#### 1.17.1.1 In-flight emergency procedures

For in-flight emergencies, *OM-A, 7.8.1* stated, "Flight Crew shall squawk 7600 and climb routing to nearest airport. Attempt shall be made to establish contact AeroGulf operations via Mobile Phone carried on the aircraft, and with ATC."

Additionally, *OM-A* stated, "AeroGulf aircraft are to be equipped with SkyTrac® equipment and emergency button shall be pressed so that Operations are aware of the in-flight emergency."

Part of the preparation for ditching, and to aid with the search and rescue, *OM-A, 8.15.2 – Ditching Considerations,* stated, "Transmit MAYDAY CALL and SQUAWK EMERGENCY (7700) while still airborne, as well as manually turning on the ELT..."

#### 1.17.1.2 Pilots training

The Investigation was informed by the Operator that most of the pilots initial training, recurrent training, and full flight simulator training and checking are outsourced including helicopter type ground school, full flight simulator and training device, night offshore flight operations, safety and emergency procedures, and all recurrent ground and refresher training. Crew resource management (CRM) and human factors training were also outsourced.

The Operator retained responsibility for oversight to ensure that the contracted training providers comply with the Operator's requirements and policy.

#### 1.17.1.3 Line training captain responsibilities

The *operations manual – part D* (*OM-D)*, outlined the responsibilities of the line training captain as follows:

"

a) Conduct of line training, in accordance with the applicable syllabus.

b) Conduct of recurrent line checks.

c) Conduct night training.

d) Conduct recurrent night checks.

e) Conduct safety emergency equipment training and checking.

f) After ensuring completion of all applicable line training requirements, and that a satisfactory level of proficiency and knowledge has been achieved, recommend a trainee to undergo a line check.

g) When authorized, conduct mission specific training and checking.

h) Familiarize pilots with all operational procedures."

#### 1.17.1.4 Night training

For training flights, the Operator issued two forms: *Initial Line Training Aerogulf/Crew Training (AGS/CT)*; and *Initial Night Check AGS/CT*, which were used by the line training captain to carry out the training requirements and assess the pilot under check.

The *Initial Line Training* form required that the sections *Statement of Training Required* and *How Training to be Delivered* to be completed and signed by the Operator's training postholder or delegate. The *Initial Night Check* was the form filled and signed by the line training captain with the assessment grading based on the flight phase and topics as stated in *OM-D,* Section *2.1.22 – Night Offshore Training Content.*

For the Accident flight, the Operator was unable to provide a copy of the *Initial Line Training* form that was used for the Pilot Undergoing Route Familiarization flight. In addition, the Operator was unable to provide copies of the *Initial Line Training* and *Initial Night Check AGS/CT* for the training flight the Instructor performed as line training captain on 6 September 2023.

*OM-D,* Section 2.1.22 – *Night Offshore Training Content*, stated:

> "The night offshore training should cover the items listed in the table below as applicable to the type of operation, and type of helicopter. For offshore pilots the night check must include at least 3 approaches and landings on an offshore platform. Where possible at least one approach and landing should be made to both a fixed structure and a movable rig or ship."

"…

| **Category** | **Element** |
|---|---|
| Pre-flight | Night weather considerations<br>Flight planning |
| Circuit | Basic night circuit<br>Let-down to circuit height<br>Use of FMS/GPS<br>Use of flight director |
| Approach and Landing | Knowledge of night approach profile<br>Crew brief<br>Approach path and speed<br>Landing<br>Overshoot/Go-around<br>PNF duties on final approach |
| Take-off | Take-off brief<br>Cockpit checks / setup<br>Take-off procedure<br>Transition to circuit<br>Departure en-route |
| General | Airmanship / Decision making<br>Crew Resource Management<br>PNF duties<br>Use of aircraft equipment<br>ATC Liaison<br>R/T operation and content |

…"

*OM-D,* Section 2.1.21, stated that for night offshore operations, the following policy applies:

> "It is company policy that every pilot who may be required to fly offshore at night, completes an initial night competency check appropriate to their role. This requirement exceeds the CAR- AIR OPS competency requirements.
> A night check is administered by a designated Training Captain. A separate night check is required for each helicopter type flown offshore at night. After the initial night check, flight crew will keep their night recency using a FFS or the real aircraft completing 3 night take off, each followed by a traffic pattern and a subsequent landings every 90 days.
> This 3 takeoff and Landing are also covering the 90 days recurrency requirements."

The Operator allows VFR flights at night as stated in *OM-A,* Section 12.28.4 – *VFR Flight at Night*, paragraph 'c', which stated, "….for night currency training conducted within controlled airspace or within a designated training area approved by the GCAA."

### 1.17.1.5 Night operations – human factors

*OM-A,* Section 8.3.1.1*,* stated the following for night operations human factors:

> "When flying at night, especially when conditions permit visual maneuvering, pilots need to consider the following human factors issues:
> a. Normal body efficiency is reduced (normal end of day fatigue and changes to the body's normal daily biorhythms);
> b. Responses are slower, due to the brain's ability to process information being slowed down;
> c. Depth perception is greatly reduced after nightfall;
> d. There is a loss of available horizon over water after dark;
> e. The single point of light displayed by the drill rig is disorientating.
>
> Company flights at night are not frequent. Even though all training and currency requirements must be met, unfamiliarity increases the risks compared to a day flight. This, combined with a lack of visual cues leads to a reduced ability to perform complex tasks, increasing the risks associated with night flying, especially offshore. The increased risks must be considered during planning night operations.
>
> All flights must operate within the minima set down in this Manual. Standard Operating Practice dictates that one pilot must remain 'on instruments' at all times until the PF calls Committed for landing. This may require a transfer of control during some approaches, but the PNF shall monitor the progress of the flight and be ready to assume control at any time. This is particularly important during the latter stages of a night approach and missed approach."

Spatial disorientation was stated in *OM-A,* Section 8.1.2.9 – *Offshore Aerodrome Minima*, stating:

> "...Reported visibilities and ceilings may not be as accurate as from onshore stations. Care must be taken in conditions of low-wind, smooth sea/poor visibility to avoid Spatial Disorientation. The Flight Director should be used whenever possible under such conditions."

### 1.17.1.6 Helicopter offshore operations

Helicopter offshore operations (HOFO) is covered under Appendix B of *OM-A*. The Operator was authorized by the GCAA to operate night offshore training flights.

*OM-A,* Appendix B – *HOFO*, Section 5.6 – *Night Offshore General Profiles*, and 5.6.1 – *Profiles (circuit)*, presented a visual aid for offshore night operations as illustrated in figure 10.

*OM-B – Performance,* Section 4, outlined *Procedure for Continued Operations to Helideck,* and for the *Take-off profile,* it is stated in paragraph 'c':

> "(1) The take-off should be performed in a dynamic manner ensuring that the helicopter continuously moves vertically from the hover to the rotation point (RP) and thence into forward flight. If the manoeuvre is too dynamic, then there is an increased risk of losing spatial awareness (through loss of visual cues) in the event of a rejected take-off, particularly at night."

The Operator's policy for night takeoff from a helideck is stated in *OM-A,* Appendix B, Section 5.2.10 – *Night Takeoff Deck/Rig/Vessel*, which stated:

> "FP actions, NFP calls,

- Committed on rotation, hold ADI 5° nose down until obtaining 55 kts Vtoss , 5° nose up, Vy (70 Kts) continue climb, (@ 60Kts floats off).
- Call positive airspeed and ROC.
- Call any torque splits, Nr or ITT, differences. Questions?

After Pre-Takeoff checks, and before lifting to the hover, visually check area clear of obstacles and pre-select take-off path heading (select HDG bug) that will suit the wind and obstructions.

Positioning the searchlight towards the rig will help the visual liftoff.

At Hover, look outside and identify a reference to the deck/rig/vessel. (NFP can check engine instruments and COMPARE ADI's are the same).

You will be committed once you rotate or lose sight of you hover reference.

Quick glances to confirm clearing the rig, and once back into the darkness hold the ADI 5° down and pre-selected heading (HDG bug). Ensure positive ROC (RADALT and altimeter can back up the VSI); the NFP will do the standard call-outs, i.e., positive ROC, airspeed alive.

At 55 KIAS apply 5° nose up and accelerate to Vy 70 KIAS."

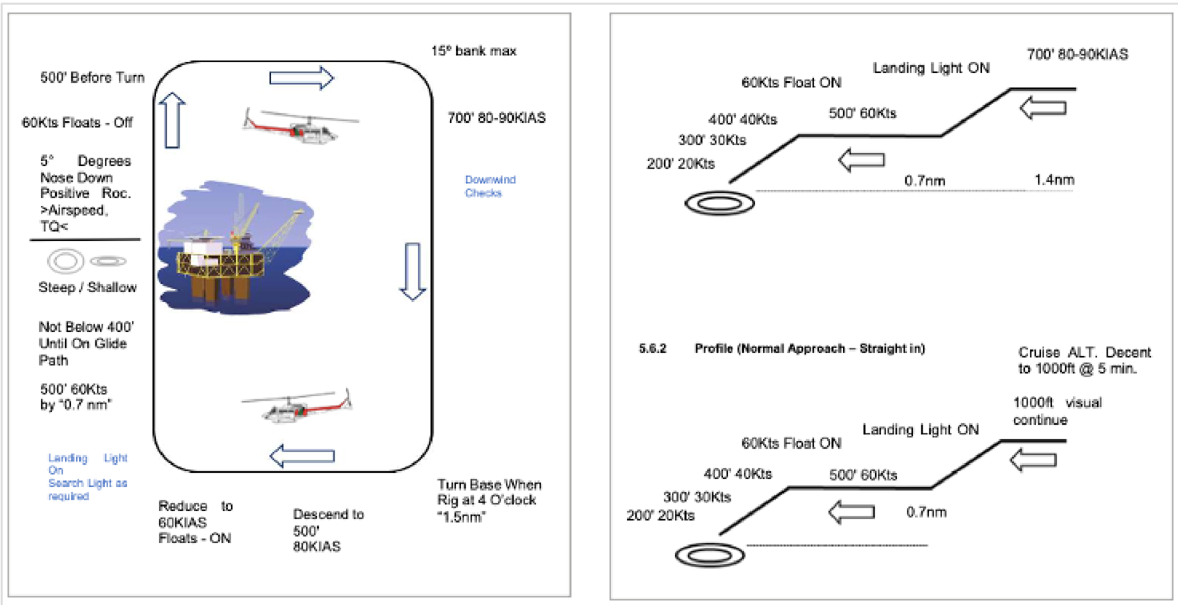


**Figure 10.** Night offshore general profiles

### *1.17.1.7 Abnormal procedures – Main Driveshaft Failure*

*Abnormal/Emergency Procedures* detailed in *OM-B* for the Bell 212 helicopter for an *Engine Over Speed – Main Driveshaft Failure,* Section 3.6.12, stated the following are the indications the crew will observe, and action required:

"…

- Left yaw
- Rapidly decreasing rotor speed
- Transitory increase with the engine N2 rotational speed.
- Caution Lights with audio
- Increased in noise level in the cabin due to over speeding and driveshaft breakage
- Immediate actions for recovery – Enter Autorotation
- Caution: 'Cockpit indications are comparable to a dual engine failure but the M/R is no longer being driven. The small ROTOR needle is rapidly decreasing and pitch must be lowered immediately. Enter autorotation immediately or rotor RPM will decay."

## 1.18 Additional Information

The requirements regarding the emergency locator transmitter are given under the *CAR-AIR OPS – Part-CAT*, *CAT.IDE.H.280 – Emergency locater transmitter (ELT),* as follows:

> "CAT.IDE.H.280 Emergency locator transmitter (ELT)
>
> (a) Helicopters shall be equipped with at least one automatic ELT.
> (b) An ELT of any type shall be capable of transmitting simultaneously on 121.5 MHz and 406 MHz."

In accordance with the *CAR-AIR OPS – Part-CAT, CAT.IDE.H.280 – Emergency locater transmitter (ELT),* the Helicopter was fitted with a fixed ELT, designed to activate automatically on impact. However, the Investigation was informed that no distress transmission was detected by SAR through the international COSPAS-SARSAT system.

The requirements regarding the cockpit voice recorder are given under the *CAR-AIR OPS – Part-CAT, CAT.IDE.H.185 – Cockpit voice recorder (CVR)*, as follows:

> "**CAT.IDE.H.185 Cockpit voice recorder**
>
> (a) The following helicopter types shall be equipped with a cockpit voice recorder (CVR):
>
> (1) all helicopters with an MCTOM of more than 7 000 kg; and
> (2) helicopters with an MCTOM of more than 3 175 kg and first issued with an individual CofA on or after 1 January 1987.
>
> …"

The requirements regarding the flight data recorder are given under the *CAR-AIR OPS – Part-CAT, CAT.IDE.H.190 Flight data recorder* as follows:

> "CAT.IDE.H.190 Flight data recorder
>
> (a) The following helicopters shall be equipped with an FDR that uses a digital method of recording and storing data and for which a method of readily retrieving that data from the storage medium is available:
>
> (1) helicopters with an MCTOM of more than 3 175 kg and first issued with an individual CofA on or after 1 August 1999;
>
> …"

The Aircraft was manufactured in 1976, and it was not equipped with CVR neither flight data recorder (FDR), as these recorders were not mandated as per the requirements.

## 1.19 Useful or Effective Investigation Techniques

The Investigation was conducted in accordance with the *Air Accident and Incident Investigation Regulation* (*AAIR*) of the United Arab Emirates, and in conformance with the AAIS approved policies and procedures, and the *Standards and Recommended Practices* of Annex 13 to the Chicago Convention.

# 2. Analysis

## 2.1 General

The Helicopter was certified as airworthy for the flight and the weight and balance was within limits. Both flight crewmembers were medically fit and certified to operate the training flight, and their licenses were current at the time of the flight.

The weather reported at the departure airport, Al Maktoum International Airport (OMDW), and at ARAS Rig was within the operating limits of the Helicopter and was not a contributory factor to this Accident.

As there was no *Civil Aviation Regulations* requirement for flight and cockpit voice recorders to be installed on the Helicopter, the analysis of the Accident was based on the limited recorded data downloaded from the SmartCycle engine health monitoring recorder. There was no equipment on the Helicopter to capture other critical flight information such as the position of the flight controls, automatic flight mode, aircraft attitude, warning indications, fuel quantity, tail rotor speed, and other flight information. The available parameters included the Helicopter airspeed, pressure altitude, main rotor speed, torque and engine parameters,

Besides the communication that occurred before the first landing between the Instructor and the Rig radio operator, there was no other communication to verify if the roles of the Instructor, as pilot monitoring, and Pilot Undergoing Route Familiarization, as pilot flying, had changed for the subsequent circuits and landings including the Accident flight. Thus, for this Report, it is assumed that the roles were maintained from the initial departure at OMDW until the impact.

Survivability is not discussed in the analysis as the impact with the sea was beyond the crashworthiness limitations of the Helicopter.

The effectiveness of training provided to the Operator’s pilots was not part of this Investigation.

## 2.2 Flight Crew Performance

Both flight crewmembers were experienced with offshore oil and gas operations, and possessed the rank of captain on the Bell 212 and Bell 412 helicopters. The Instructor had accumulated about 9,000 flight hours on various types of helicopters (Bell 212, Bell 412, and AW169), whereas the Pilot Undergoing Route Familiarization had accumulated about 7,000 flight hours.

At the Operator, the Instructor and Pilot Undergoing Route Familiarization had flown many missions as pilot flying and as pilot monitoring to offshore rigs during the day-time operations. However, as flying to offshore rigs was not a regular operation for the Operator, their offshore rig helideck Bell 212-night flight experience, especially in the 90 days before the Accident, was limited to Instructor.  In the 90 days before the Accident, the Pilot Undergoing Route Familiarization never conducted any offshore rig night flights, as he was not authorized, and his planned initial night training flight on the Bell 212 on 7 September 2023 was his first in almost a year.

For the night departure under visual flight rules (VFR), the en-route weather remained within the operating limitations of the Helicopter and did not pose a threat to the safety of the flight. The visibility was at least 7 kilometres in clear and cloudless skies. The sea was considered normal, which would not have affected the landing at the ARAS Rig helideck. When the Helicopter departed OMDW at 1918, after about 47 minutes from sunset, and by the time the Helicopter reached the Rig, the astronomical twilight had ended at 1948. As there was no moonlight, the skies would have been lit with stars and the sea water would have been dark.

The routing of the flight after departure from OMDW made it possible for the Pilot Undergoing Route Familiarization to have visual light reference from the seacoast as he turned northeast towards the ARAS Rig as he was seated in the right cockpit seat. Prior to the first approach to the ARAS Rig, communication was established by the Instructor with the Rig radio operator announcing the expected time of arrival for the first landing. Besides passing weather information, the Rig radio operator did not receive any reports indicating safety concerns with the Helicopter.

After 32 minutes of departure from OMDW, the flight crew executed the first controlled and uneventful landing on the Rig helideck at 1950. Thereafter, another two uneventful circuits were flown including the takeoff and landing, which were in compliance with the Operator's *operations manual – part A* (*OM-A*) – *Night Offshore General Profiles.*

During the first two take-off circuits flown around the Rig, the Helicopter's direction allowed the flight crew to maintain visual reference of the lighted coastline, enhancing their situational awareness of the Helicopter's position relative to the sea and the Rig.

The landing of the second circuit flight was controlled and uneventful, and the Helicopter landed 14 minutes after the first landing, coming from OMDW at about 2004. The Helicopter remained on the helideck longer than during the previous two landings and stayed on the deck for more than three minutes. There is no evidence to the Investigation of a safety concern with the Helicopter or either flight crewmember during this period, since there was no radio transmission made by any of them.

As the Helicopter hovered above the helideck, the direction was changed from the landed southeast position to a northwest direction. When climbing, the Helicopter quickly gained about 600 feet pressure altitude in 40 seconds briefly levelling off at 1,000 feet pressure altitude before starting descending. The average rate of climb was over 900 feet per minute within this period. The maximum airspeed during the climb was 60 knots, which occurred 25 seconds after the departure as the Helicopter ascended passing 680 feet pressure altitude. As the Helicopter continued to climb towards 1,000 feet pressure altitude, the airspeed was decreasing rapidly below 20 knots. Thereafter, the Helicopter started a rapid descent with about 1,070 feet per minute from 1,000 feet to 750 feet with airspeeds below 20 knots. The Helicopter continued the rapid descent with increasing airspeed to 105 knots and impacted the water at a rate of descent of more than 2,400 feet per minute. The impact occurred approximately 27 seconds from the top of descent. The flight time from takeoff until impact was about 67 seconds.

Unlike the first two circuits, the takeoff during the third circuit involved a heading change by the pilot flying (the Pilot Undergoing Route Familiarization) that resulted in the loss of the Rig as a visual reference. This take-off profile was not consistent with the Operator's *OM-A*, Section 5.2.10 — *Night Takeoff Deck/Rig/Vessel*, which requires the selection of a heading that maintains the Rig as a reference during the initial climb. The Helicopter climbed rapidly to approximately 1,000 feet pressure altitude, and the dynamic nature of the maneuver was not aligned with the guidance provided in *OM-B*, Section 4 — *Performance*, which defines the take-off profile for continued operations to the Rig.

As the Helicopter passed 680 feet pressure altitude, the sudden reduction in the airspeed that never exceeded 60 knots, is consistent with the flight crew possibly reacting to a developing situation in the cockpit, coinciding with a recorded reduction in both engine torque. Both engines and rotor were operating normally as the Helicopter continued climbing towards 1,000 feet pressure altitude. During the rapid descent until the impact, the only change was an increase in both engines' torque with the engines' parameters and rotor speed showing no significant change.

The possible factors influencing this rapid rate of climb towards 1,000 feet could have been the reduction in fuel weight, the positive headwind component, and the pilot flying (the Pilot Undergoing Route Familiarization) control inputs to achieve a positive rate of climb. At the time of the final takeoff, the Helicopter was already about 50 minutes in flight and would have been a minimum of 393 pounds lighter because of the fuel consumption. During this phase of initial climb, the operating procedure would have required the pilot flying to establish a visual reference point, while the pilot monitoring (the Instructor) maintains a continuous instrument scan and verifies the Helicopter's attitude, speed, and rate of climb including the flight director.

Based on the data recorded by the SmartCycle system, and given the lack of direct information regarding instrument scanning patterns, the Investigation could not establish, with certainty, whether appropriate instrument cross-checking was maintained by the flight crew during the final phase of descent.

## 2.3 Human Factors

### 2.3.1 Night operations

Both the Instructor and the Pilot Undergoing Route Familiarization were designated senior management positions and would have worked together addressing operational hazards. Both of them had attended the required recurrent training for crew resource management and line checks. They would have been aware of the human factors affecting pilots' performance and limitations, especially during moonless night operations.

Helicopter operations supporting offshore oil and gas industry have experienced several accidents, with many attributed to human factors affecting pilot performance. Similar to other accidents, the human-machine interface introduced a potential for errors to occur. The Investigation believes that the flight crew's ability to process information accurately began to degrade after the Helicopter turned away from the Rig and during takeoff into the darkness of the sky, losing both horizon and earth reference, further aggravated by the black sea surface. Approximately 20 seconds after initiating the dynamic climb maneuver on takeoff, conducted at an average climb rate of 900 feet per minute, the flight crew likely experienced spatial disorientation[3], probably exacerbated by insufficient instrument cross-checking.

The Operator's *operations manuals* acknowledge the threats associated with night operations, particularly the risk of spatial disorientation when external visual references are limited or absent. During the final dynamic climb maneuver, the likely spatial disorientation may have adversely affected their ability to accurately perceive the situation of the Helicopter's attitude and control inputs. This impairment in spatial orientation likely contributed to degraded flight performance and may have prevented timely recovery of the Helicopter's flight path. This condition of spatial disorientation was stated in the Operator's *OM-A Operating Procedures,* Section 8.1.2.9 – *Offshore Aerodrome Minima*, and *OM-B 'Performance',* Section 4 – *Procedure for Continued Operations to Helideck,* for the *'Take-off profile'.*

### 2.3.2 Inadequate rest

The Investigation was unable to conclusively determine whether fatigue had any influence on the performance of the flight crewmembers, beyond the information available from the recorded duty roster. The roster for September 2023 indicated that the Pilot Undergoing Route Familiarization had been off duty for more than 24 hours prior to the Accident flight, and was therefore likely adequately rested.

The Instructor, however, had completed the final day of a three-day postholder classroom course conducted during daytime hours from 5 to 7 September 2023. On 6 September 2023, the Instructor attended the course from approximately 0730 to 1500 and subsequently conducted a night training flight at the ARAS Rig helideck, departing OMDW at

[3] 'Spatial disorientation is a term used to describe a variety of incidents occurring in flight where the pilot fails to sense correctly the position, motion or attitude of his aircraft or of himself within the fixed coordinate system provided by the surface of the Earth and the gravitational vertical. In addition, errors in perception by the pilot of his position, motion or attitude with respect to his aircraft, or of his own aircraft relative to other aircraft, may also be embraced within a broader definition of spatial disorientation i flight.' [Source: Benson, 1988]

1848 and returning after approximately two hours. The total duty period of 13 hours 18 minutes (0730–2048), as defined in *CAR-OPS 3.1105* and *3.1106* and Operator's *operations manual – part A (OM-A),* paragraphs 7.1.9 and 7.1.10[4], exceeded the standard two-pilot maximum flight duty period (FDP) for a 0700–0759 start, which is 11 hours under *CAR-OPS 3.1110* and *OM-A, paragraph 7.1.11*[5]. There was no evidence of a split-duty credit or any approved extension being applied in accordance with *CAR-OPS 3.1117* and *OM-A, paragraph 7.1.12*[6].

On 7 September 2023, the Instructor followed a similar schedule. The Instructor again attended the course from 0730 to approximately 1500, and later conducted a night training flight from OMDW at 1918 to the ARAS Rig helideck. The Accident occurred at 2007 during the third circuit of the training exercise, representing an FDP of 12 hours 37 minutes up to the time of the Accident. Had the flight continued as planned for five circuits and returned to OMDW, the FDP would have reached about 13 hours 35 minutes. Both exceeded the allowable maximum FDP.

The rest period between the two FDPs (2048 to 0730 = 10 hours 12 minutes) was shorter than the minimum required rest, defined as the greater of 12 hours or the preceding duty period, as required by *CAR-OPS 3.1120 OM-A,* paragraph 7.1.13[7]. Consequently, the Instructor commenced the 7 September FDP after a reduced rest.

Under *CAR-OPS 3.1125(d)*[8], a commander may not exercise discretion to extend an FDP following a reduced rest. Therefore, any extension on 7 September 2023 would not have been permissible. In addition, there were no Operator's procedures concerning a commander's discretion to extend an FDP.

The Investigation concluded that the 6 and 7 September FDPs exceeded the prescribed flight duty time limitation (FDTL), and the intervening rest period was insufficient. The resulting duty/rest pattern was therefore non-compliant with *CAR-OPS 3*, Subpart Q, and no evidence was found of any specific documented exceptions such as an approved fatigue risk management system (FRMS), Operator exemption, split-duty authorization, or commander's discretion report.

The Investigation verified the existence of FDP exceedances and reduced rest periods. Non-compliance with flight and duty time limitations constituted an organizational safety deficiency and is assessed to have, most probably, contributed to the Instructor not adequately rested, with a consequent degradation of operational performance.

In the Accident night, the sea surface was illuminated by an extremely low level of light, representing near-total natural darkness. It was a level where the human eye can typically still function but is well below what is needed for any detailed or routine task.

The nature of the offshore operation, the darkness of the sea, together with the composition the cockpit crew which comprised an Instructor who was not adequately rested , and a Pilot Undergoing Route Familiarization to that location during night conditions, for the first time, degraded the cockpit performance in a high attention-demanding conditions.

When the Helicopter took off on the final departure from the Rig, the Instructor, as the pilot monitoring, was responsible to monitor the instrumentation and call out any abnormalities.

4 *CAR-OPS 3.1105/3.1106* and *OM-A,* paragraph 7.1.9 and 7.1.10 – *Calculation rules and additional limits* (how to calculate FDP, late finishes/early starts, standby, positioning).

5 *CAR-OPS 3.1110* and *OM-A,* paragraph 7.1.11 – *Maximum FDP* (table for single / two pilots; start-time bands). Table with 07:00–07:59: two pilots maximum FDP = 11 hours.

6 *CAR-OPS 3.1117* and *OM-A,* paragraph 7.1.12 – *Extension of FDP by split duty* (rules for split-duty extension amounts).

7 *CAR-OPS 3.1120* and *OM-A,* paragraph 7.1.13 – Rest periods (minimum rest = whichever is greater: preceding duty period or 12 hours; reductions and special rules).

8 *CAR-OPS 3.1125* – *Commander's discretion to extend an FDP* (commander may extend up to 3 hours maximum after FDP has commenced; cannot exercise discretion after a reduced rest).

In addition, he was responsible for taking over the controls from the Pilot Undergoing Route Familiarization when the latter was unable to continue flying for whatever reason.

The degraded performance in the cockpit could not restore the situational awareness of the pilots that could have been impaired by the spatial disorientation. This disorientation was caused by the lack of horizon reference, moonless dark night and heading (northwest) the Helicopter in a direction that left the Rig light behind.

## 2.4 Organizational Control of Night Training and Flight Preparation

The Instructor, acting as both the line training captain and pilot monitoring, was responsible for ensuring that the Pilot Undergoing Route Familiarization, who was acting as the pilot flying and undergoing a line check, is familiar with 'all operational procedures' and demonstrated 'satisfactory level of proficiency and knowledge'. It was considered a normal practice at the Operator for the line training captain to determine if more than three training circuits were required as well as to determine the pattern of the circuits. However, except for the *OM-A 'Night Offshore General Profiles',* there was no specific guidance from the *operations manuals* on what pattern the circuits had to be flown at the Rig during the night-time training sessions to achieve a satisfactory level of proficiency.

The Investigation could not determine why the Instructor had planned for five training circuits, as the Operator was unable to provide a copy of the *Initial Line Training AGS/CT* form as the printed original form was with the Instructor during the Accident flight. This form would have provided information such as *statement of training required* and *how training to be delivered*. The Operator did not have a policy of keeping a copy of this form at the departing station as well as there was no digital version available.

Even though the Pilot Undergoing Route Familiarization, under his initial night training, was an experienced Bell 212 helicopter pilot, he was not familiar with offshore rig night flights performed during a moonless night. Factors affecting a pilot's performance and the risks in such unfamiliarity were clearly stated in *OM-A 8.3.1.1*, which must be considered during planning night operations. The Instructor and the Pilot Undergoing Route Familiarization should have taken these threats into consideration as part of the training flight planning and pre-flight briefing. However, the Investigation was unable to confirm what pre-flight planning and risk management mitigation actions were required to be discussed between the both pilots for the initial night training flight, as there were no documented pre-flight records made available to the Investigation.

Despite the multiple layers of safety defenses, the Operator had put in place, including procedures and crew training, this night-time Accident indicated that there were weaknesses within the Operator's planning of night training flights and flight briefing procedures which did not effectively address how to detect and manage threats and errors, which could have prevented the Helicopter undesirable state, thus maintaining safe operation of the Helicopter. The Investigation concludes that the flight crew's preparedness for the training flight could have been enhanced through the use of a documented checklists requiring a pre-flight discussion and assessment of the specific risks to flight safety associated with the planned training circuits.

## 2.5 The Helicopter

The Helicopter was airworthy for the flight and there were no signs of technical anomalies during the flight.

As scheduled by the Bell 212 maintenance program, the Helicopter main driveshaft was replaced, and balanced, approximately one month before the Accident flight. Thereafter, the two flights conducted before the Accident date did not have any pilot reports concerning vibration with the driveshaft. In addition, no maintenance defects were noted during the pre-flight inspections following the installation.

During the post-Accident inspection at the Helicopter manufacturer's facilities, grease was found on the main rotor transmission housing, and analysis of the grease confirmed that it most likely originated from the main driveshaft coupling. The grease splatter on the housing was most likely caused by the high-speed impact of the helicopter with the sea, which resulted in the separation of several parts, including the main driveshaft. As the driveshaft rotated at a high speed until impact, it is possible the grease splatter occurred when the driveshaft coupling became detached from the transmission housing.

The Investigation reviewed the consequences of the main driveshaft separation as a possible contributing factor to this Accident. For this scenario, it would have required the flight crew to carry out memory actions based on the *Abnormal/Emergency Procedures* detailed in the *OM-B,* Section 3.6.12 for the Bell 212 helicopter for an *Engine Over Speed – Main Driveshaft Failure.*

Based on the retrieved SmartCycle engine data, there was no indication that the driveshaft had failed, as there was neither a rapid decrease in rotor speed nor a transient in the engine N2 rotational speed. Furthermore, the engine manufacturer's post-Accident examination report confirmed that both engines and the main rotor were operating normally up until the impact.

The Investigation concludes that the drive shaft was installed and remained intact until the impact with the sea.

## 2.6 The Organizational Factors

Over the period 2019 to 2023, successive audits conducted under *CAR-OPS 3* requirements revealed a pattern of systemic deficiencies within the Operator's training system, flight and duty time limitation practices, and organisational oversight processes. Although individual findings were closed following each audit, the recurrence of similar non-conformities across multiple years indicates that the underlying causes were not fully addressed.

During the General Civil Aviation Authority (GCAA) annual audits over the period from 2019 to 2022 (the last annual scheduled audit before the Accident), the Operator was repeatedly found to have non-compliances with the flight duty time limitation (FDTL) management. These included incorrect calculation of duty periods, unreliable or inaccurate rostering and recording processes, and recurrent errors within the digital scheduling system. The audits also documented the absence of formal FDTL training for both flight crew and rostering personnel, including insufficient instruction on circadian rhythms, sleep disruption, and fatigue risk. The Operator did not maintain a functional fatigue reporting culture, and fatigue hazards were not properly reflected within the safety risk register. In addition, several findings noted that the conditions for the use of commander's discretion, including reduced rest, were not clearly documented, and in some cases, roster violations were neither flagged nor reported.

Training-related findings were similarly persistent. Across multiple years, audit teams identified the absence of minimum training-requirement policies at crew recruitment, incomplete or missing training records, deficiencies in recurrent and crew resource management (CRM) programs, and insufficient control of instructor competencies. Recordkeeping was frequently ineffective and did not provide reliable evidence that flight crew met the training and checking requirements of *CAR-OPS 3*. These deficiencies probably limited the Operator's ability to ensure the continued competence of operational personnel.

The organisational dimension of the findings was further characterised by inadequate document control, outdated manuals, and deficiencies in compliance monitoring. By 2023, the post-Accident audit revealed a considerable number of overdue findings, insufficient staffing within the compliance monitoring function, delayed audit close-outs, and weaknesses in the independence of auditing activities. The manpower plans demonstrated shortage within the quality and safety management systems oversight, reducing the Operator's ability to detect and correct non-compliances in a timely manner.

When considered collectively, the audit history revealed a long-term pattern in which deficiencies in fatigue management, duty-time compliance, and training oversight persisted despite repeated regulatory findings. This pattern is directly relevant to the circumstances surrounding the Accident. The Investigation established that on the day preceding the Accident, one of the flight crewmembers (the Instructor) conducted an FDP exceeding the *CAR-OPS 3* maximum for the applicable start time. The subsequent rest period was shorter than the minimum required rest, and the following day's FDP again exceeded the allowable limits. As the rest was reduced, the Instructor was not legally permitted under *CAR-OPS 3.1125* to extend the FDP using discretion, yet the planned and actual FDP lengths exceeded the regulatory maxima. These exceedances were not prevented by the rostering system nor identified through operational oversight.

The probable contribution of the FDTL exceedance to the Accident is consistent with the types of systemic deficiencies repeatedly documented from 2019 to 2022. The inaccuracies within the rostering system, the lack of adequate dispatcher and scheduler training on fatigue management, the insufficient procedural safeguards regarding reduced rest and commander discretion, and the absence of robust fatigue hazard controls all represent latent organisational conditions that could have allowed non-compliant duty schedules to develop.

The findings revealed during the GCAA post-Accident audit, conducted on 30 November 2023, further demonstrated that these systemic issues remained unresolved at the time of the occurrence. The presence of overdue findings and insufficient compliance monitoring capacity indicates that the Operator lacked an effective mechanism to ensure sustained regulatory compliance or to address recurring FDTL and training deficiencies. As such, the findings recorded after the Accident were consistent with, and represented a continuation of, the patterns identified in earlier years.

Subsequent to the 2023 audit, a series of oversight activities conducted by the GCAA identified changes within the Operator's management system, including two replacements of senior management between 2024 and 2025. In parallel, the GCAA noted continuing management-related challenges, limitations in the effectiveness of the safety management system, and an increasing volume of reports associated with supervisory functions. On the basis of these observations, the GCAA concluded that an increased level of safety oversight is appropriate.

Accordingly, and in line with Risk-Based Oversight (RBO)[9] principles, the GCAA initiated its On-Notice Program (ONP)[10] for the Operator, with effect from 1 July 2025. This action required the Operator to submit, within 14 days, a comprehensive action plan addressing the non-compliances identified during previous GCAA audits, including defined deliverables and implementation timeframes. During the ONP period, the Operator was subject

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9 The GCAA applies a Risk-Based Oversight (RBO) policy founded on the principles of a safety management environment, enabling a dynamic and evidence-based assessment of an organisation's safety performance. Under this policy, the scope, depth, and frequency of regulatory surveillance are adapted and calibrated in proportion to the operator's actual safety performance, the level of risk to which the organisation is exposed, and the demonstrated capability of the organisation to effectively identify, assess, and manage its own safety risks. This adaptive oversight approach supports the effective implementation of the State Safety Programme (SSP) and contributes to the achievement of national and organisational safety objectives.

10 The GCAA may apply the ONP when an organization exhibits conditions such as financial instability that could affect continued operations, the occurrence of significant or increasing incidents that are not effectively investigated and may indicate underlying systemic issues, a demonstrated weakness in regulatory compliance, or instability or ineffectiveness within management or nominated postholder functions.

to augmented oversight activities by the GCAA, with the objective of supporting regulatory compliance and, where applicable, adjustments to operational scope.

The GCAA informed the Investigation that in the event the Operator is unable to submit an acceptable corrective action plan or to achieve implementation within the agreed timelines, further regulatory actions can be considered, including limitations or suspension of the organizational approvals. This approach is intended to promote corrective actions that addressed systemic aspects of the management system and supported sustained compliance, as well as an acceptable level of safety performance.

Following the commencement of the ONP, the Operator submitted an action plan covering the period from July to December 2025 for both the air operator certificate and the approved maintenance organization. The plan addressed the non-compliances identified by the GCAA and the required actions, including additional actions arising from reports and GCAA-directed investigations. It identified replacement of postholders, implementation schedules, and measurable outcomes for each action. The plan also introduced a monitoring framework, including periodic progress reporting to the GCAA, to facilitate oversight, verification of action closure, and ongoing regulatory monitoring. The Operator indicated that the actions would be implemented within the agreed timeframes and that supporting documentation would be made available to demonstrate alignment with applicable regulatory requirements.

The Air Accident Investigation Sector considered that the post-Accident enhanced oversight measures established by the GCAA are aligned with the organizational issues identified during the Investigation. It is assessed that, provided the associated corrective actions are implemented as planned and remain consistent with the identified root causes, these measures have the potential to address the underlying systemic deficiencies and support the restoration of the Operator’s effective compliance and safety management.

# 3. Conclusions

## 3.1 General

From the evidence available, the following findings, causes and contributing factors were made with respect to this Accident. These shall not be read as apportioning blame or liability to any particular organization or individual.

To serve the objective of this Investigation, the following sections are included in the conclusions heading:

- **Findings-** are statements of all significant conditions, events or circumstances in this Accident. The findings are significant steps in this Accident sequence but they are not always causal or indicate deficiencies.
- **Causes-** are actions, omissions, events, conditions, or a combination thereof, which led to this Accident.
- **Contributing factors-** are actions, omissions, events, conditions, or a combination thereof, which, if eliminated, avoided, or absent, would have reduced the probability of the Accident occurring, or mitigated the severity of the consequences of the Accident. The identification of contributing factors does not imply the assignment of fault or the determination of administrative, civil or criminal liability.

## 3.2 Findings

### 3.2.1 Findings relevant to the Helicopter

(a) The Helicopter was certified, equipped, and maintained in accordance with the *Civil Aviation Regulations* of United Arab Emirates, and was airworthy when dispatched for the flight

(b) The Helicopter was not equipped, nor it was required to be equipped, with a flight data recorder (FDR) or cockpit voice recorder (CVR) according to the *CAR-AIR OPS, Part- CAT*.

(c) The Helicopter was equipped with a Pratt & Whitney SmartCycle recorder which was used for engine health monitoring.

(d) The SmartCycle electronic unit was recovered, and the data stored in the built-in memory, including that of the Accident flight, was successfully downloaded by the manufacturer.

(e) The Helicopter's weight and balance were within limits for the flight.

(f) No distress transmission was detected by the SAR through international COSPAS-SARSAT system.

(g) The uncontrolled and significant impact forces affecting the structure of the cockpit with the seawater exceeded the Helicopter's crashworthiness design requirements, making human survivability not possible. The Helicopter was destroyed due to the impact forces.

(h) The recovery of the Helicopter's wreckage took five days.

(i) Part of the fuselage, the cockpit instrument panel, both engines, and a part of one rotor blade were recovered.

(j) The main driveshaft and tail rotor assembly were not recovered.

(k) The airspeed decreased to between 0 and 20 KIAS, and a high rate of descent the airspeed rapidly and continuously increased, reaching 105 knots just before impact with the sea.

### 3.2.2 Findings relevant to the flight crewmembers

(a) The flight crewmembers were licensed and qualified for the flight in accordance with the requirements of the *Civil Aviation Regulations* of the United Arab Emirates.

(b) The Instructor was an Operator's flight safety officer and he was issued a provisional approval by the General Civil Aviation Authority (GCAA) as a postholder crew training on 26 May 2023 for a validity of three months. The Instructor was subsequently issued another provisional approval on 7 August 2023, with validity up to 7 November 2023.

(c) The Instructor was attending a three days postholder course during the period from 5 to 7 September 2023, as a requirement for postholder permanent approval.

(d) The Instructor's 6 and 7 September FDPs exceeded the prescribed flight duty time limitations (FDTL), and the intervening rest period was insufficient.

(e) The Pilot Undergoing Route Familiarization was the Operator's chief pilot.

(f) The Instructor was a captain and authorized to fly Bell 212 and Bell 412 for day and night flights.

(g) The Pilot Undergoing Route Familiarization was a captain and authorized to fly only day flights on Bell 212, and day and night flights on the Bell 412.

(h) The night training flight on 7 September 2023 was their first night flight together.

### 3.2.3 Findings relevant to the flight operations

(a) Prior to the last circuit, the flight was conducted in accordance with the procedures outlined in the Operator's *operations manuals*.

(b) The flight was conducted at night under visual flight rules.

(c) The weather reported at the ARAS Jack-up Driller Rig was within the operating limits of the Helicopter and was not a contributing factor to the Accident.

(d) The Helicopter reached the Rig about 47 minutes after sunset.

(e) There was no moonlight as the moon was expected to rise above the horizon around midnight.

(f) The AFCS was checked for correct operations during the flight crew pre-flight checks in accordance with *RFM 2-6G "AFCS CHECK" Normal Procedures.*

(g) The Helicopter crash occurred during the take-off phase of the third circuit training flight at ARAS Rig.

(h) The first two circuits at ARAS Rig were uneventful, and were flown in accordance with the Operator's policy outlined in *OM-A – Night Offshore General Profiles* and *Night Takeoff Deck/Rig/Vessel.*

(i) The takeoff of the third circuit was not executed in accordance with the *OM-A* in terms of the need for selecting a heading that maintains the Rig as reference.

(j) During the takeoff of the third circuit training flight, the Helicopter average rate of climb was 900 feet per minute.

(k) The engine manufacturer's examination report stated that the speed was reduced to between 0-20 KIAS in the climb phase and then increased up to 105 KIAS at the time of impact.

(l) The Helicopter rate of descent over the last 13 seconds until impact was more than 2,400 feet per minute.

(m) No 'Mayday' call or 'squawk emergency (7700)' was transmitted by the flight crew.

### 3.2.4 Findings relevant to the Operator

(a) The Operator's *emergency response plan* was immediately activated following the crash.

(b) Most of the Operator's pilot operational training, including crew resource management and human factors, was outsourced, while the Operator maintained the final responsibility in accordance with the applicable provisions of *CAR-OPS 3*.

(c) For the Accident flight, the Operator was unable to provide a copy of the *Initial Line Training AGS/CT* form that was used for the Pilot Undergoing Route Familiarization flight, neither for the training flight the Instructor has performed as line training captain on 6 September 2023.

(d) The Operator was contracted to provide night standby and medevac support at ARAS Rig.

(e) The post-Accident oversight, conducted by the GCAA, identified instability in the Operator's management system, including changes in senior management, together with persistent safety management and supervisory weaknesses. These conditions resulted in an elevated risk profile and the need for enhanced regulatory oversight to ensure sustained compliance and acceptable safety performance.

### 3.2.5 Findings relevant to search and rescue

(a) Within 10 minutes, a recovery team from ARAS Rig was deployed to the area of the Accident site.

(b) After one hour from the Accident occurrence, the search and rescue operation commenced after the arrival of the search and rescue team along with the Coast Guard.

(c) Both flight crewmembers suffered fatal injuries.

(d) The body of the Pilot Undergoing Route Familiarization was recovered from the area of the crash site within 12 hours, whereas the Instructor's body was found on the third day of the search.

## 3.3 Causes

The Air Accident Investigation Sector determines that the most probable cause of the controlled flight into terrain Accident was the spatial disorientation due to limited external visual references during night operations, resulting in degrading the pilots' situational awareness and impairing their ability to maintain proper attitude and level-off maneuver. The degraded situational awareness disabled the pilots from preventing the high rate of descent, and taking timely and effective recovery actions.

## 3.4 Contributing Factors

The Air Accident Investigation Sector determines that the most probable contributing factor to the controlled flight into terrain was degraded cockpit performance during a dark night flight, compounded by the cockpit crew composition, specifically an Instructor who was not adequately rested under the applicable prescriptive scheme, and a Pilot Undergoing Route Familiarization to that location, during night conditions, for the first time.

# 4. Safety Recommendations

## 4.1 General

The safety recommendations listed in this Report are proposed according to paragraph 6.8 of *Annex 13 to the Convention on International Civil Aviation* and are based on the conclusions listed in Part 3 of this Report. The Air Accident Investigation Sector expects that all safety issues identified by the Investigation are addressed by the receiving States and organizations.

## 4.2 Final Report Safety Recommendations

**Aerogulf Services**

**SRxx/2026**

The Investigation identified that the degradation of situational awareness resulted from spatial disorientation, compounded by inadequate instrument cross-checking and non-adherence to night offshore operational procedures. The combination of an Instructor who was not adequately rested under the applicable prescriptive scheme and a Pilot Undergoing Route Familiarization to ARAS Rig location for the first time under night conditions, did not enable the flight crew to recover situational awareness and respond accordingly.

The existing training framework and operational guidance did not sufficiently mitigate the elevated risks associated with night offshore flight operations, particularly in reduced visual reference environments.

Therefore, it is recommended that Aerogulf review and enhance the flight training and operational oversight system to ensure the effectiveness of risk controls associated with high-risk operations, such as night offshore flights.

This may include, but not be limited to:

- Strengthening training system design through the integration of scenario-based training modules that realistically replicate night offshore operational environments and the challenges of spatial disorientation.
- Revising instructor assignment and supervision policies to ensure that crew composition appropriately balances experience levels and duty limitations, thereby reducing the risk of fatigue-induced performance degradation.
- Establishing performance monitoring and feedback mechanisms to evaluate the effectiveness of existing procedures, flight instruction, and guidance in managing operational risk.
- Incorporating lessons learned from this occurrence into the safety management system (SMS) to identify and address organizational factors contributing to risk control failures in flight training and operational planning.

**SRxx/2026**

The Investigation determined that, although the presence of fatigue could not be conclusively verified, the Instructor's flight duty period (FDP) had exceeded the maximum limits prescribed under *CAR-OPS 3*, Section 3.1110, representing a breach of duty time regulations.

This exceedance, coupled with insufficient rest opportunity, created a latent organizational risk that weakened fatigue-related risk controls. The probability of fatigue-induced performance degradation was assessed as plausible, given the

Instructor’s extended duty day following a full daytime classroom course and prior night operations.

The night offshore operational environment during the occurrence was characterized by extremely low ambient illumination, lack of visual horizon, and featureless over-water conditions. All of which significantly increase cognitive and perceptual workload.

The combined effect of inadequate rest, limited experience, and challenging environmental conditions likely contributed the spatial disorientation, and inadequate monitoring of flight instruments, ultimately preventing effective recovery from the upset condition.

It is recommended that Aerogulf review and strengthen its organizational controls and operational policies related to fatigue risk management and crew pairing in high-risk helicopter operations, particularly for night offshore flights, to ensure that operational risks are systematically identified, mitigated, and continuously monitored within the framework of the SMS.

This Report is issued by:

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# Appendix A: SmartCycle data showing final departure until impact