Norwegian Safety Investigation Authority

Issued February 2024

REPORT AVIATION 2024/03

Serious aviation incident on 24 February 2020 near the Maersk Invincible (XMKI) oil rig in the North Sea involving Sikorsky Aircraft Corporation S-92A, LN-ONT, operated by Bristow Norway AS

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The Norwegian Safety Investigation Authority (NSIA) has compiled this report for the sole purpose of improving flight safety.

The purpose of the NSIA's investigations is to clarify the sequence of events and causal factors, elucidate matters deemed to be important to the prevention of accidents and serious incidents, and to make possible safety recommendations. It is not NSIA's task to apportion blame or liability.

Use of this report for any other purpose than for flight safety should be avoided.

Photo: L3 Harris Technologies UK/SHK

Legal authority for the Norwegian Safety Investigation Authority's activities is enshrined in Section 12-1 of the Act of 11 June 1993 No 101 relating to aviation (Aviation Act); cf. Section 3 of the Regulations of 19 December 2014 No 1848 on public investigations of accidents and incidents in civil aviation.

This report has been translated into English and published by the NSIA to facilitate access by international readers. As accurate as the translation might be, the original Norwegian text takes precedence as the report for reference.

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Report on serious aviation incident

Table 1: Data relating to the aviation incident

Type of aircraft:	Sikorsky Aircraft Corporation S-92A
Nationality and registration:	Norwegian, LN-ONT
Owner:	Bristow Equipment Leasing Ltd, Grand Cayman, Cayman Islands
Operator:	Bristow Norway AS
Crew	2, uninjured
Passengers:	9, uninjured
Incident site:	Maersk Invincible (XMKI), Valhall on the Norwegian continental shelf, after take-off. Position N 56°14’ 99’’ E 003° 20’ 93’’
Time of incident:	At 20:56 hrs on Monday 24 February 2020

Unless otherwise stated, all times referred to in this report are local times (UTC + 1 hour).

Notification of the incident

This serious aviation incident was reported to the Norwegian Safety Investigation Authority (NSIA) by Bristow Norway AS on 25 February 2020 using the reporting form *NF-2007 Occurrence reporting in civil aviation*. After a preliminary investigation, the NSIA decided to initiate an investigation on 19 March 2020. The NSIA then notified the European Aviation Safety Agency (EASA), the Norwegian Civil Aviation Authority (CAA-N) and the National Accident Investigation Board in the USA (National Transport Safety Board – NTSB) of the investigation. The NTSB appointed an accredited representative who assisted during the investigation.

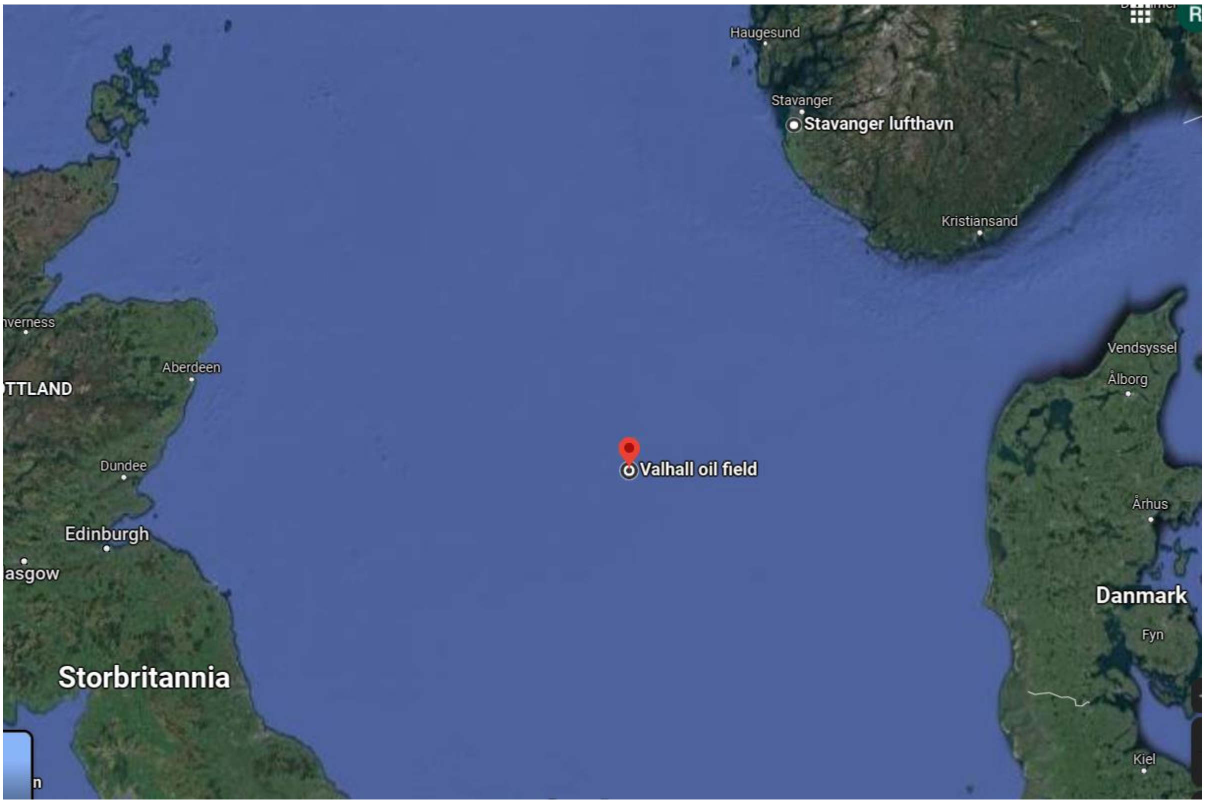

Figure 1: At the time of the aviation incident, the Maersk Invincible jackup rig was part of the Valhall complex. Source: Google Maps

Summary

The crew of the Sikorsky S-92A helicopter lost control of the helicopter shortly after take-off from the helipad on the Maersk Invincible oil installation. The departure was made in the dark and under demanding conditions where the crew had no external horizon or external visual references.

Following the take-off from the helideck, the helicopter lost altitude, heading and airspeed. This led to a significant deviation from a normal and stable departure profile. The crew lost control of the situation, and the helicopter accelerated rearwards with a high nose, over a distance of 210 m north of the platform and to the left of the planned flight route. At the same time, the helicopter lost more altitude. One minute after take-off from the platform, the pilots regained control. They had then been out of control for about 40 seconds. When control was regained they were at an altitude lower than the height of the helicopter deck from which the helicopter took off. This was just over a minute after departure from the platform. They then established a controlled and steady climb before setting course for Stavanger Airport Sola. The helicopter continued the flight to Sola without further incidents.

On the evening of 24 February 2020, the helicopter LN-ONT, a Sikorsky S-92A, operated as BHL-352, was ready for take-off from the Maersk Invincible jackup rig's helideck. The helicopter was operated by Bristow Norway AS. It carried nine passengers and a flight crew of two pilots. The plan was to take off into the wind, accelerate evenly while climbing to 1,000 ft, and then head for Stavanger Airport Sola (ENZV). It was dark, with strong winds and rain, and the two pilots had no visual horizon outside the aircraft. The oil rig was behind the helicopter, so the flight crew saw only darkness in the flight direction. The first officer in the left-hand seat had the role of Pilot Flying (PF), and the captain in the right-hand seat had the role of Pilot Monitoring (PM).

The investigation has not revealed any technical errors or faults relating to the helicopter that could have influenced the course of events. The incident occurred in demanding weather conditions during departure from the Maersk Invincible oil installation before the autopilot's minimum speed (V-min) had been reached.

The crew did not conduct a separate briefing to reveal any particular threat for this departure. The NSIA considers that it would be appropriate to reveal special dangers for the flight in question (Threat) to be prepared to deal with them. Threat and Error Management (TEM) is described in the helicopter operator's Expanded Checklist. This investigation shows that the possibility of omitting important safety elements related to departure under particularly demanding conditions is still present. Active use of TEM to highlight threats to safe flight must be reflected in the daily operation.

The Norwegian Safety Investigation Authority (NSIA) recommends that The Norwegian Civil Aviation Authority (CAA-N) in its supervisory role for offshore helicopter operators emphasize following up the operators' procedures and routines related to TEM, TEM training and how TEM is managed in daily operations.

The NSIA finds that the first officer, who was pilot flying, probably was subject to a sensory illusion as a result of the combination of head movement and both the vertical and horizontal acceleration during the transition to instrument flight after the Take-off Decision Point. The phenomenon occurred unexpectedly and probably triggered spatial disorientation. The disorientation accompanied by overcorrection of the flight controls then brought the helicopter out of position for normal flight profile during take-off. Whether it was done intentionally or not, use of the cyclic trim release button to set the correct pitch-up attitude to climb and trim out the resistance in the cyclic probably contributed to aggravate the situation.

For a period, also the commander, who was pilot monitoring, was disoriented. They were in a stressful situation and the commander himself has described that the CRM did not work as expected during this period. When the commander made visual contact with the oil installation on the right side of the helicopter, he regained his situational awareness and took over the flight controls.

The helicopter was flown manually, and as a result of the pilot who was at the flight controls becoming disoriented, the helicopter came out of control with a high nose pitch-up attitude. In the helicopter operator's Standard Deviation Calls, deviation calls for abnormal pitch variations do not exist. The NSIA considers that the absence of standard deviation calls for abnormal pitch variations can contribute to miscommunication and misunderstandings during the attempt to regain a correct flight profile. Regarding this the NSIA issues a safety recommendation to the helicopter operator Bristow.

About the investigation

Purpose and method

The NSIA has classified the incident as a serious aviation incident. The purpose of the investigation has been to determine what caused LN-ONT to lose altitude, speed and heading on 24 February 2020 after taking off from the Maersk Invincible jackup rig. The NSIA has also analysed why it happened and considered what can be done to improve safety and prevent the recurrence of similar incidents in the future.

The incident and the circumstances surrounding it have been investigated and analysed in line with the NSIA's framework and analysis process for systematic safety investigations (the NSIA method[1]).

Sources of information

The following have been among the most important sources of information:

- The NSIA's interviews with the crew.
- Data from the combined voice and flight data recorder (CVFDR) and animation of the flight based on those data.
- Information obtained from the helicopter operator, the European Union Aviation Safety Agency (EASA), the US Federal Aviation Administration (FAA) and Sikorsky Aircraft Corporation.
- The helicopter operator's internal procedures and investigation report.
- The oil rig's helideck report.

The investigation report

The first part, 'Factual information', describes the history of the flight, related data and information gathered in connection with the incident, as well as NSIA findings.

The second part, the 'Analysis' part, contains the NSIA's assessment of the sequence of events and contributing factors based on the first part of the report. Circumstances and factors found to be of little relevance to explaining and understanding the incident are not discussed.

The final part of the report contains NSIA's conclusions and safety recommendations.

[1] *NSIA – Norwegian Safety Investigation Authority. See https://www.nsia.no/About-us/Methodology*

1. Factual information

1. Factual information

1.1 History of flight

1.1.1 PLANNING AND PREPARATION

The captain and the first officer had completed a round trip flight together between Stavanger Airport Sola and the Gyda platform earlier that day. The flight took place in daylight, but in relatively poor weather conditions with rain and icing.

At Stavanger Airport Sola, while planning the flight to Maersk Invincible[2] (XMKI), the aircrew assessed the possibility of helicopter-triggered lightning when flying in snow showers. Hence extra fuelling at Sola was needed to be able to navigate around the snow showers. The planning was otherwise completed in accordance with the helicopter operator's Standard Operating Procedures (SOP).

The flight time to Maersk Invincible was estimated to be 1 hour and 18 minutes. The total fuel quantity on leaving Sola was 4,923 lbs.

1.1.2 THE FLIGHT FROM ENZV TO MAERSK INVINCIBLE

The crew has told the NSIA that the flight from Sola to Maersk Invincible was completed in accordance with the plan. Since the reported wind direction at XMKI indicated that the first officer would carry out the landing,[3] he had the role of Pilot Flying (PF) on the outbound flight. The captain had the role of Pilot Monitoring (PM). The approach to the oil rig was carried out as a standard airborne radar approach (ARA) and followed by a close to standard 90° landing, with the first officer operating the flight controls.

The captain has explained to the NSIA that he left the helicopter to monitor the hot refuelling, and to inspect the helicopter in accordance with the helicopter operator's procedures. It rained heavily and he was drenched when he returned to start preparing for departure, board a total of nine passengers and stow their luggage.

A helideck report was prepared at 18:00 hrs, almost three hours before take-off; see Figure 2. According to the report, the height of the helideck on Maersk Invincible was 78.9 m (259 ft). The report also showed that the helideck orientation was 136°, and that a wind of 42 kts with gusts of 47 kts was blowing from 120°. When the report was prepared, horizontal visibility was 7,000 m, it was almost overcast with broken clouds (BKN) and the cloud base at 900 ft; see Figure 2.

Based on the wind direction, it was the first officer who would execute the take-off. He would therefore have the role of PF while the captain in the right seat would have the role of PM.

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[2] Maersk Invincible is one of Maersk Drilling's Class I rigs, with the designation 'ultra harsh environment jack-up drilling rig'. It can accommodate up to 180 persons in single-berth cabins.
[3] The ideal committal point when landing on a helideck is 50 ft above the height of the helideck with the rotor tangential to the helideck periphery and a ground speed of 10 kts. From the committal point, the helicopter should approach the centre of the helideck at an angle of 45 degrees. The wind direction at the oil rig is therefore one of several factors that decide who should make the landing.

HELIDECK REPORT	Installation: Maersk Invincible
	Email: opertech.invincible@maerskdrilling.com
	Tel: +47 52016497
Date: 24.02.2020 — Time (UTC): 17:00	Position: 56°14´99´´N - 03°20'93´´E
Dynamic positioning: ○ Yes ◉ No	NDB: 534 kHz
Accurate monitoring equipment: ◉ Yes ○ No	VHF: 118,050 mHz

LOG INFO

Flight number: BHL 352	Helifuel available: ◉ Yes ○ No	Fuel quantity: 2500 Litres
Return load: 9 pax Passengers		Luggage (incl. In total): 280 lbs kg
Total weight: 2357 lbs kg		Cargo (incl. In total): 7 lbs kg

Routing:	1 SVG	2 MIV	3 SVG	4

The helideck is inspected according to OLF helideck manual. Nonconformities will appear under Remarks.

For Deck Clear 130,550 MHZ

Remarks:

WEATHER OBSERVATION

WIND	Height:	Distance:	Direction:	Velocity:	Gust (2 min):
Helideck:	78,9 M	n/a M	120	42 kn	47 kn
Area (derrick):	n/a M	n/a M	n/a	n/a kn	n/a kn

Visibility: 7000 M	QNH: 993 hPa	Helideck heading: 136	Vessel heading: 136
Temperature: 3,0 Degrees C	Dewpoint: 1,8	Clouds (few / sct / bcn / ovc in feet): BKN 009	
Other relevant weather info (fog banks, rapid changes, etc):			
Sea spray observed over helideck: ○ Yes ◉ No			

Figure 2: The helideck report from Maersk Invincible at 18:00. Source: Maersk Drilling / NSIA

1.1.3 THE TAKE-OFF FROM MAERSK INVINCIBLE

In addition to interviews, data from the combined cockpit voice and flight data recorder (CVFDR) have been used to describe the take-off. The crew told the NSIA that, with the rain beating against the front windows, it was impossible to see any form of horizon in the dark. The searchlight was positioned to throw the light straight forward. The entirety of the oil rig with its lights and lit structures, which could have provided visual references, was behind the helicopter.

The commander completed the Offshore Pre-Takeoff Checklist. At 19:56 hrs, the first officer brought the helicopter into a 5-ft hover above the helideck and prepared to take off into the wind. The commander has explained that it felt as if the helicopter moved forward while hovering, and that he almost lost sight of the visual references along the edge of the helideck in front of the helicopter. The helicopter's heading was 101° at the time.

When the commander had completed the hover check, the first officer moved the collective to 80% torque to start a vertical climb to the take-off decision point (TDP). This was in accordance with the procedures in the helicopter operator's Operations Manual B 2.2.6 Helideck Take-off*.* The CVFDR showed that the helicopter had a nose-up pitch of approximately 8° on its vertical climb to TDP.

During departures from oil rig helidecks, TDP is the point used by the pilots during the vertical climb to determine whether to abort the take-off and return to the helideck or continue the take-off through Engine Failure Point 1 (EFP1) with a possible forced landing or a continued take-off through Engine failure Point 2 (EFP2). If an engine stops before reaching TDP, the pilots shall abort the take-off. If an engine stops at or after TDP, and if passed the (EFP2), the helicopter will be capable of continuing the take-off by accelerating to the take-off safety speed (VTOSS), and then to the best rate of climb speed (Vy). For take-offs from oil rig helidecks, TDP is 30 ft above the level of the helideck.

When the commander called TDP at 19:56:18 hrs, the first officer moved the cyclic gradually forward to a 5° nose down pitch to initiate horizontal acceleration. A 5° nose-down pitch is in accordance with the helicopter manufacturer's recommendations and the helicopter operator's procedures for take-off from a helideck in night-time conditions or poor weather with reduced horizontal visibility. The torque was 74% on both engines.

While accelerating, the helicopter had a low sink rate and the torque varied between 70 and 79%. The commander, who was pilot monitoring, has told the NSIA that he focused his attention on the vertical speed indicator. When it showed a sink rate of 100 ft/min, he called out '*We are descending'* two times. Just after that, the voice alert '*Altitude, altitude – altitude, altitude'* indicated that the helicopter was about to drop below the minimum altitude selected on the radar altimeter. The radar altimeter was set to 260 ft after the radar approach to Maersk Invincible. The commander has explained that, after the voice alert, he got the feeling that the instrument readings did not match with what he expected, and he felt that he became disoriented, see Figure 4.

A few seconds afterwards, when the helicopter had accelerated to approximately 35 kts at an altitude above sea level of 306 ft, the nose angle increased by 6.4° per second to more than 25° nose up pitch; see Figure 3. At the same time, the indicated horizontal airspeed dropped to zero. During this phase, the torque of both engines dropped to 66% before it was increased to 88%. The first officer compared the experience like being in the simulator where you don't experience the sensation of acceleration.

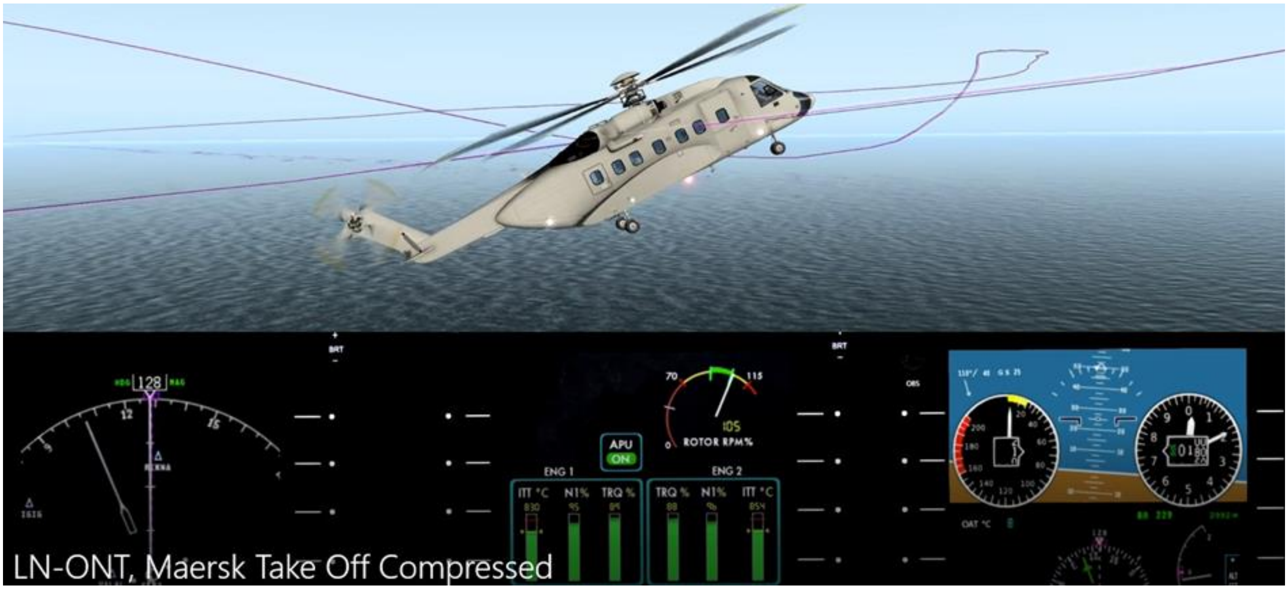

Figure 3: The highest pitch-up attitude after take-off exceeded 25° while the helicopter was accelerating rearwards and reached a ground speed of 49 kts. Animation: L3 Harris Technologies UK / NSIA. Source: LN-ONT CVFDR

The helicopter then developed a nose-up pitch in excess of 20° for approximately 15 seconds while moving sideways to the left, after which it started to accelerate rearwards and downwards. During that phase, the helicopter nose turned to the right, from 103° to 155°. With 89% engine torque, the helicopter continued to lose altitude at a vertical speed of more than 375 ft/min for 10 seconds.

The FDR showed that the helicopter travelled backwards with a ground speed exceeding 30 kts for 12 seconds, and that the maximum recorded rearward speed was 49 kts; see Figure 5 and Figure 6. In total, the rearward flight covered a distance of approximately 210 m north of the platform. The shortest distance between the centre of the helideck and the helicopter's rearward flight route was calculated to be 201 m; see Figure 7. The lowest radar altitude during this phase was 210 ft above sea level.

Replaying the helicopter's voice recorder (CVR), it became clear that, during the phase when the helicopter was moving rearwards nose-up, the first officer became confused about who was in control. The first officer first expressed uncertainty as to whether the commander was operating the controls at TDP + 23 seconds. Initially, the commander replied in the negative. The commander did confirm that he was operating the controls 11 seconds later, which was TDP + 34 seconds.

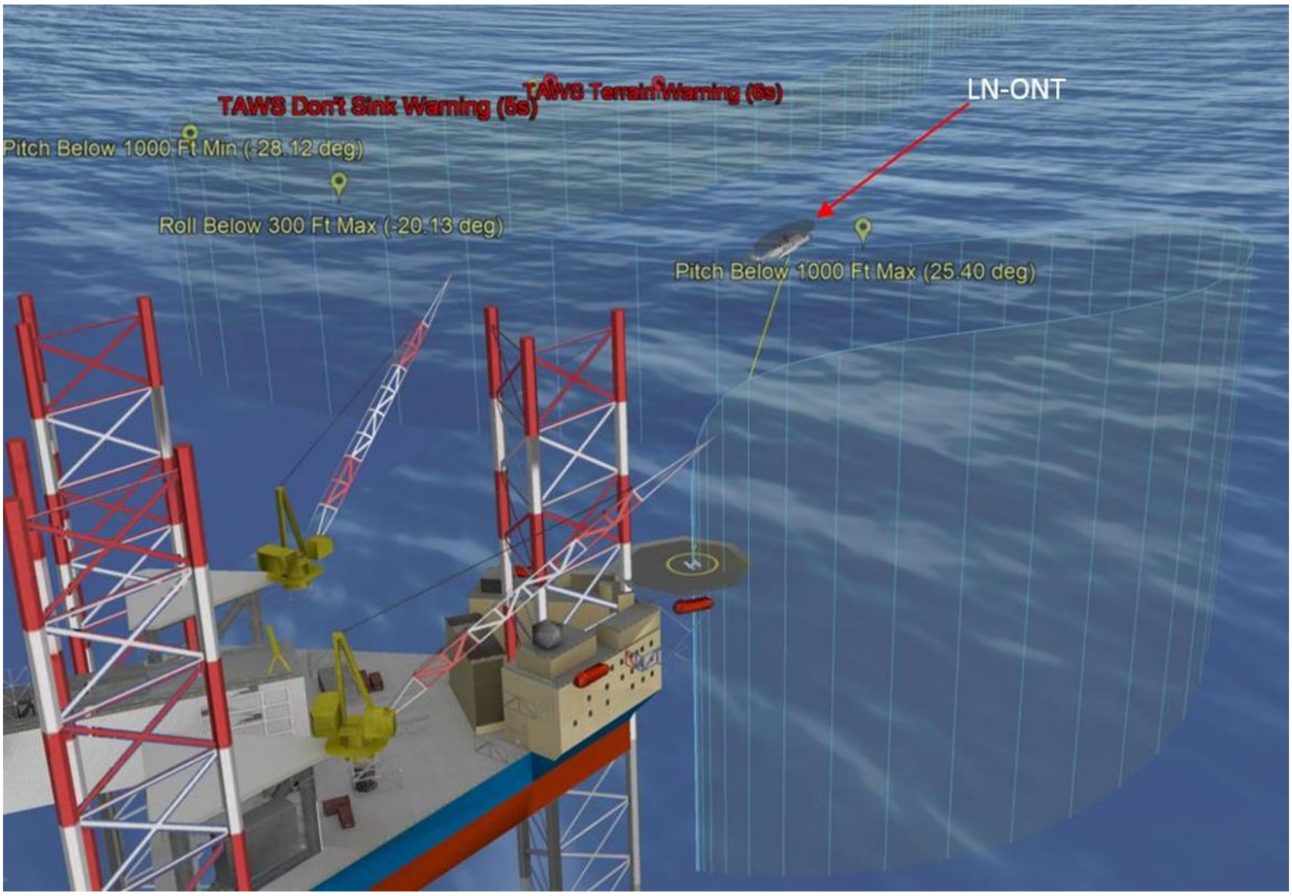

Figure 4: The helicopter's departure profile during the seconds following its take-off from Maersk Invincible. Warnings from the enhanced ground proximity warning system (EGPWS) are highlighted in red. Illustration: L3 Harris Technologies UK / NSIA. Source: LN-ONT CVFDR

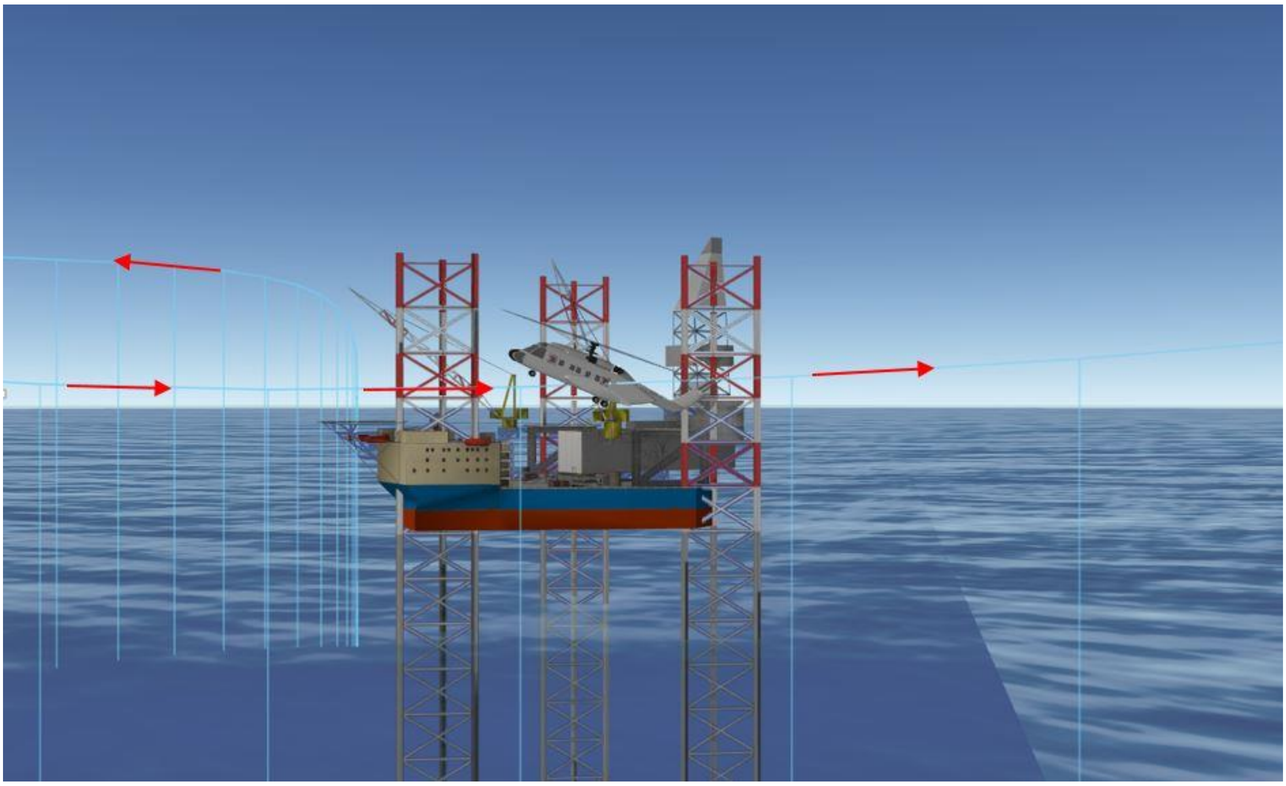

Figure 5: A still image from the animation shows LN-ONT accelerating rearwards towards its highest ground speed of 49 kts. Animation: L3 Harris Technologies UK / NSIA. Source: LN-ONT CVFDR

Figure 6: Animation of LN-ONT passing the oil installation while the helicopter flies backwards. (The oil installation is an illustration and not identical to Maersk Invincible). Animation: L3 Harris Technologies UK / NSIA. Source: LN-ONT CVFDR

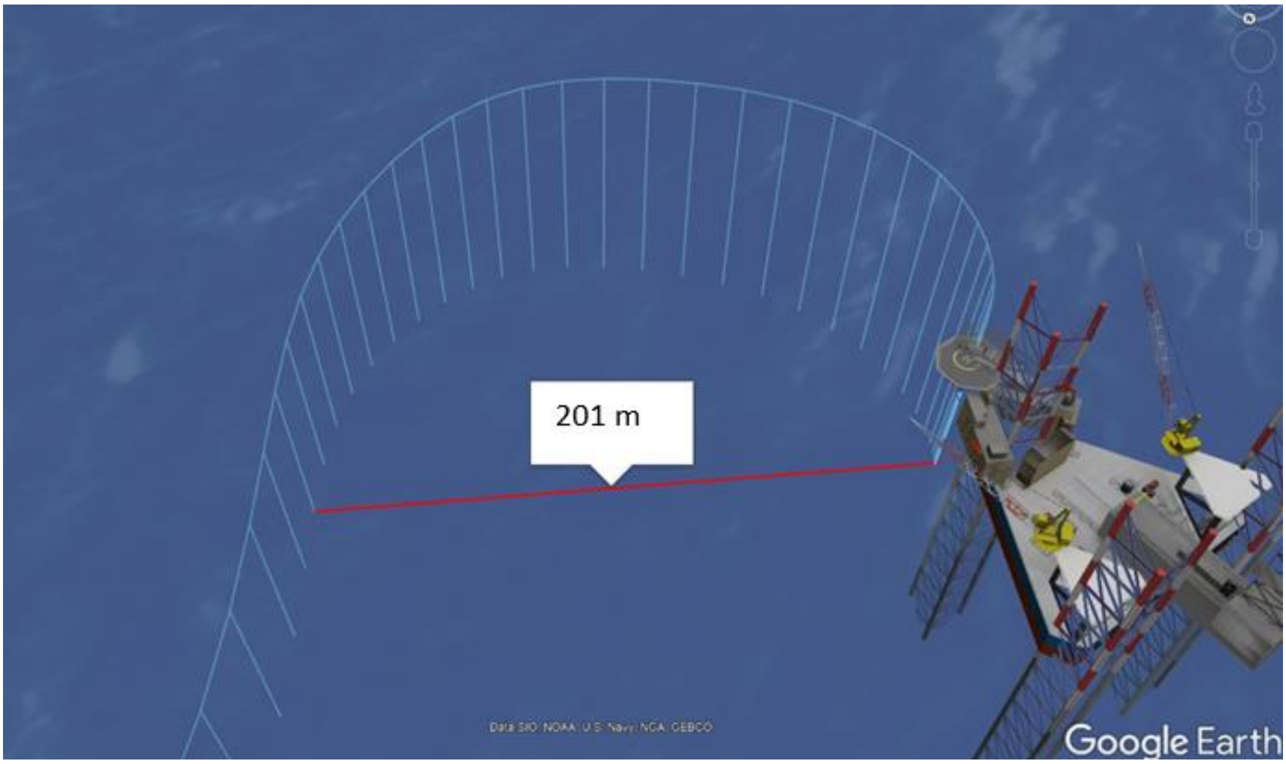

Figure 7: The shortest distance between the centre of the helideck and the helicopter's rearward flight route was calculated to be 201 m. Animation: L3 Harris Technologies UK / NSIA. Source: LN-ONT CVFDR

TDP + 31 seconds, 49 seconds after the first officer had lifted the helicopter into a hover, looking right the commander made visual contact with the oil installation they had just taken off from; see Figure 6. Simultaneously the helicopter was drifting sideways towards the left away from the platform while the nose was turning left from approximately 160° to 90°.

The commander has explained to the NSIA that, during this phase, he was primarily focusing his attention on the artificial horizon indicator, and that he understood that the first officer was struggling to gain control of the situation. He also explained that, once he had taken over the controls, he pressed the force trim release button to stabilise the helicopter. The first officer was still at the controls, however, as he wanted to make sure that the commander had actually assumed control of the helicopter.

Before the subsequent acceleration, while the commander sought to regain control, the helicopter reached a maximum nose-down pitch of 28.12°; see Figure 8. The engine torque briefly dropped to 64% before it was corrected to 88% as the horizontal speed gradually increased to 90 kts.

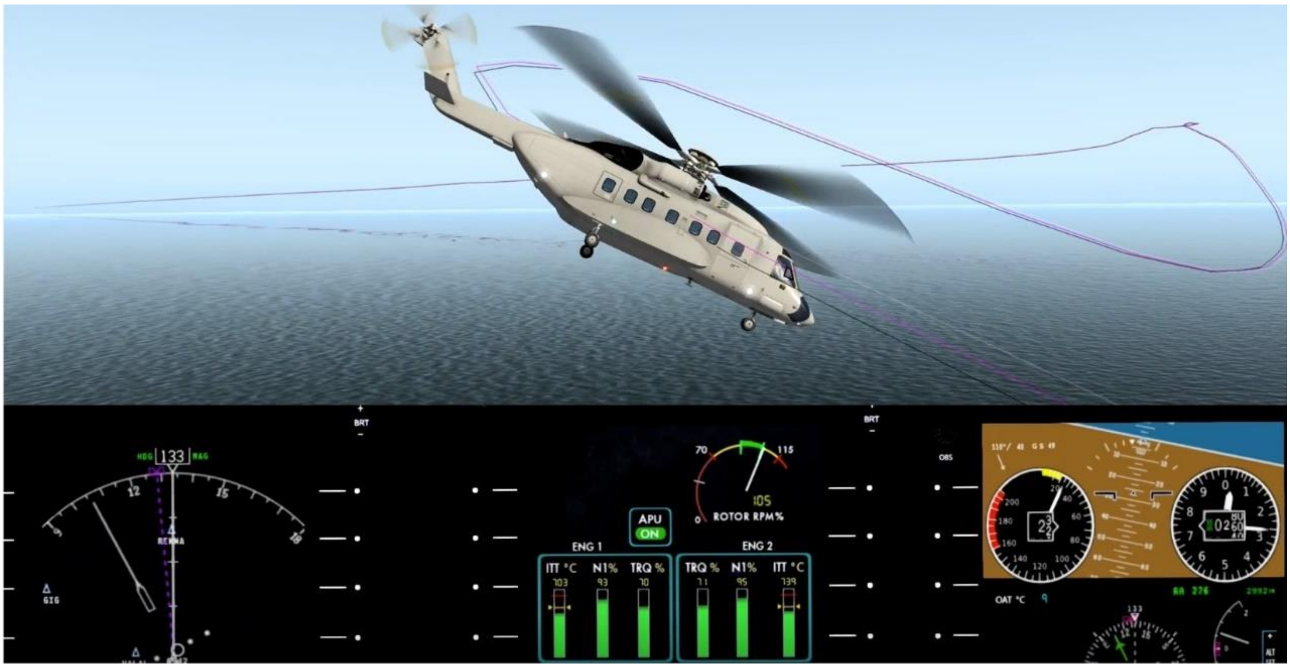

Figure 8: While attempting to regain control of the helicopter, it developed a nose-down pitch of 28.12°. Animation: L3 Harris Technologies UK / NSIA. Source: LN-ONT CVFDR

1.1.4 REGAINING CONTROL

At 19:57:07 hrs, TDP + 49 seconds, the terrain warning system (EGPWS) was activated. This was after the crew was in the process of regaining positive control and the helicopter accelerated and lost altitude. The system then transmitted the warnings '*Don't sink, don't sink'* and *'Warning terrain, warning terrain, warning terrain'* three times to the pilots' headset; see Figure 4. These warnings were also displayed visually on the instrument panel. The helicopter's lowest registered radar altitude above the sea was 175 ft, and the highest sink rate was 870 ft/min. The helicopter was out of control for a period of approx. 40 seconds.

While climbing and at a speed of 69 kts, the commander asked the first officer to activate the autopilot mode *Altitude Pre-select – ALT.P*,[4] to maintain the pre-selected altitude. Heading, speed, pre-selected altitude hold and vertical climb speed were activated on the helicopter's autopilot at 19:57:37 hrs. A stable speed of 80 kts was subsequently achieved and the pilots established a stable eastward climb-out to a cruising altitude of 1,000 ft before heading in the direction of Sola. The pilots have informed the NSIA that they maintained this altitude while flying towards the mainland.

En route, the crew noticed vibrations and concluded that it was because the landing gear had not been retracted. The vibrations disappeared as soon as this was done.

After landing at Sola, the crew gathered the passengers at the helicopter terminal and informed them of the incident in line with the helicopter operator's procedures regarding undesirable incidents.

[4] Altitude Pre-select – ALT.P is an autopilot mode that automatically causes the helicopter to level out at a pre-selected altitude after a descent or a climb.

1.2 Injuries to persons

Table 2: Injuries to persons

Injuries	Crew	Passengers	Others
Dead			
Serious			
Minor/none	2	9	

1.3 Damage to aircraft

None.

1.4 Other damage

None.

1.5 Personnel information

1.5.1 COMMANDER

The commander had the role of Pilot Monitoring (PM) during the take-off from Maersk Invincible.

The commander, 42 years old, had 15 years of experience as a military helicopter pilot, of which 8 years as a maintenance test pilot and 9 years as an instructor.

He had been employed as a pilot with Bristow Norway AS since January 2014, and as a senior first officer since February 2015. He had attended a flight commander course at Bristow in June 2015 and has flown as commander on the helicopter operator's S-92A helicopters since then.

At the time of the incident, the commander held an ATPL(H) commercial pilot licence for helicopters and a multi-engine instrument rating ME IR(H) valid until 31 March 2020, in addition to a Class 1 medical certificate without limitations, valid until 3 March 2020. He held a valid operator proficiency check (OPC) for the helicopter type, valid until 31 March 2020.

At the time of the incident, the commander was employed in 80% of a full-time position, and he had performed eight night-time helideck landings during the last 90 days.

Before starting work that day, he had had a rest period of 10 hours and 15 minutes, preceded by a standby period.

The commander had attended crew resource management (CRM) training at Bristow Norway AS on 11 February 2015 and most recently attended CRM training on 14 September 2019.

Table 3: Flight time, commander (Pilot Monitoring – PM). Source: Bristow

Flight time	All types	Relevant type
Past 24 hours	6	6
Past 3 days	6	6
Past 30 days	37	37
Past 90 days	73	73
Total	6,750	2,191

1.5.2 FIRST OFFICER

The first officer was 39 years old and had the role of Pilot Flying (PF) during the take-off from Maersk Invincible.

He had previously worked as a helicopter pilot for Bristow US, where he had flown Bell 206 and Bell 407 helicopters serving the offshore oil and gas industry in the Gulf of Mexico for eight years. All helicopter flights had been conducted in daylight in accordance with visual flight rules (VFR).

The first officer gained employment with Bristow Norway AS in March 2019 and got his first officer rating on the S-92A in May that year.

At the time of the incident, the first officer held a commercial pilot licence for helicopters CPL(H) and a multi-engine instrument rating ME IR(H) valid until 30 April 2020. His Class 1 medical certificate was without limitations and valid until 11 February 2021. He had most recently attended simulator training on the helicopter type in October 2019, passing his fist operator proficiency check (OPC) on the S-92A. The OPC was valid until 30 April 2020.

He had performed a total of 11 night-time helideck landings during the past 90 days. The first officer has informed the NSIA that, during the past 12 months, he had had approximately 211 hours of night-time flying in total, including 84 hours on the helicopter type. The flight on which the incident occurred was the second that day. It was also his first day back at work after an off duty period of nine days.

The first officer had received CRM training on 3 May and 28 October 2019.

Table 4: Flight time, first officer (Pilot Flying – PF). Source: Bristow

Flight time	All types	Relevant type
Past 24 hours	3	3
Past 3 days	3	3
Past 30 days	24	24
Past 90 days	144	144
Total	5,800	605

1.6 Aircraft information

1.6.1 GENERAL INFORMATION ABOUT SIKORSKY S-92A

The Sikorsky S-92A is a conventionally configured heavy passenger helicopter with two engines, one four-blade main rotor rotating anti-clockwise when seen from above, and one four-blade tail rotor. In the offshore configuration, it is designed to carry up to 19 passengers and 2 pilots. A full-scale version of the helicopter type was first presented in 1992. After completion of development and testing, a type certificate was issued by the US Federal Aviation Administration (FAA) in 2002, and a type certificate for Europe was subsequently issued by JAA[5]/EASA in 2004. The helicopter was first put into service in Norway in 2007, to carry workers to and from offshore oil facilities. As a result of the accident with a Super Puma helicopter EC 225 in 2016, the S-92A is as of February 2024 the only helicopter type used in this service on the Norwegian continental shelf.

As of 31 December 2019, 44 individual S-92A type helicopters were registered in the Norwegian Civil Aircraft Register, 25 of them operated by Bristow Norway.

1.6.2 HELICOPTER DATA

Table 5: Data relating to LN-ONT. Source: Bristow/NSIA

Manufacturer:	Sikorsky Aircraft Corporation (SAC) S-92
Serial number:	920070
Year of manufacture:	2007
Airworthiness:	Airworthiness Review Certificate (ARC) EASA Form 25 2008-0163 expiration date 10. Mars 2020
Total flight time:	16,643 hours
Engines:	2 General Electric CT7A
Fuel:	Jet A-1
Maximum take-off mass:	12,020 kg (26,500 lbs)
Mass at the time of the incident:	10,827 kg (23,869 lbs)
Never-exceed speed:	165 kts

Figure 9: Bristow Sikorsky S-92A. Illustration photo: Bristow/NSIA

[5] *The Joint Aviation Authority (JAA) was a European regulatory authority for civil aviation and the predecessor of EASA.*

1.6.3 AERODYNAMIC CHARACTERISTICS

When the speed of a helicopter is increased after take-off, the increased airflow through the rotor system will pitch up the helicopter's nose. In helicopter aerodynamics, this phenomenon is also known as 'blowback'. Some fundamental helicopter theory is illustrated in Figure 10 and Figure 11. In order to compensate for the pitch-up tendency while flying manually, the pilot must apply forward cyclic at a rate commensurate with the rate at which the nose is pitching up, so that acceleration can continue. If the pilot fails to compensate, the nose of the helicopter may pitch up significantly, resulting in deceleration.

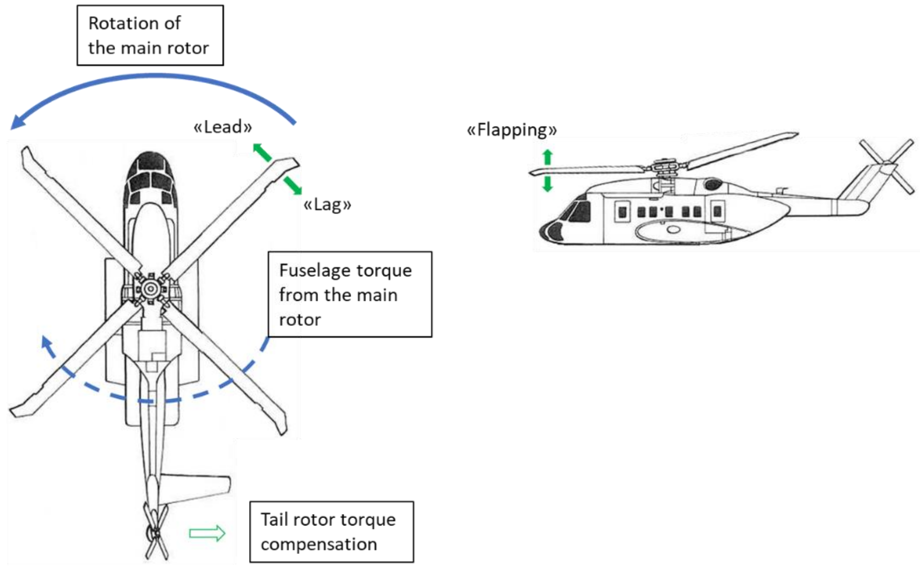

Figure 10: The illustration shows the torque generated by the rotation of the main rotor and acting on the fuselage, and the tail rotor compensating for the torque to control the helicopter's attitude. The figure also illustrates flapping and lead/lag. Illustration: NSIA

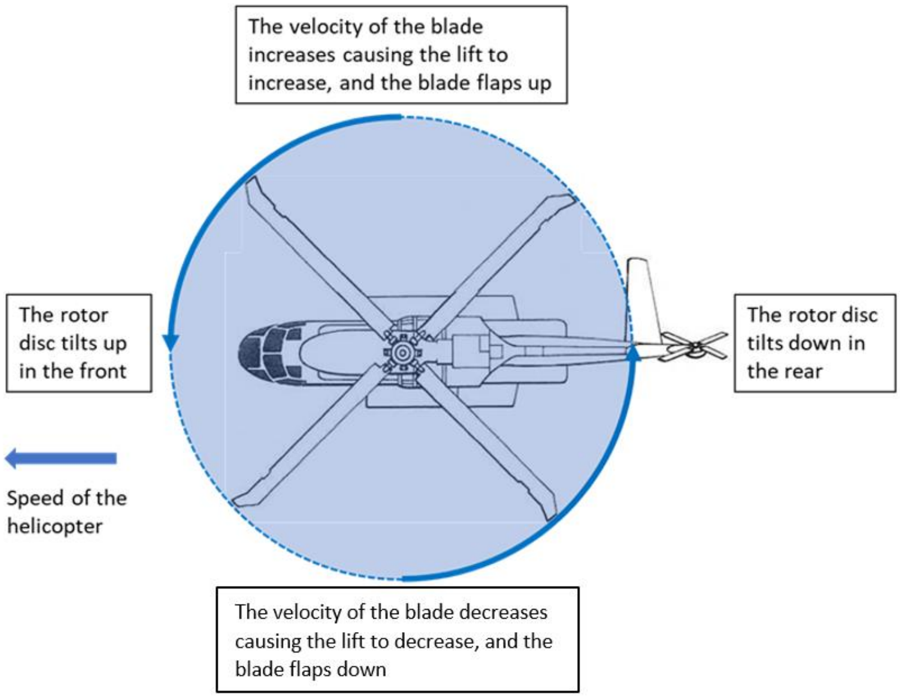

Figure 11: Blowback – the aerodynamic effect of the main rotor blades flapping upwards when they move forward on the right-hand side and flapping downwards when they move rearwards on the left-hand side. The phase lag of the blade's impact on the rotor disc due to the natural oscillation of each individual blade causes the rotor disc to tilt upwards in front of the helicopter nose and over the tail boom. Illustration: NSIA

1.6.4 ENHANCED GROUND PROXIMITY WARNING SYSTEM (EGPWS)

Today, recently manufactured medium-heavy and heavy helicopters certified for instrument flying are equipped with an enhanced ground proximity warning system (EGPWS). The system is designed to warn the pilots both visually and by aural alerts if the helicopter is moving inadvertently towards the ground, sea or obstacles defined in the system's database.

LN-ONT was equipped with a Honeywell Aerospace Engineering MK XXII EGPWS. According to the *S-92 Pilot Training Manual,* it is designed to alert the pilots in time to take corrective action to prevent impact with the terrain – controlled flight into terrain (CFIT).

The EGPWS basic modes receive information from the radar altimeter and are designed to prevent impact with flat or sloping terrain. The improved 'enhanced' modes are based on satellite navigation and compare GPS position with the terrain and known obstacles in a database. The enhanced mode is deactivated when the indicated airspeed is below 70 kts.

The six different EGPWS modes are described in the flight manual and in the S-92 Pilot Training Manual; see Appendix A.

Mode 3 warns of loss of altitude after take-off. In the present incident, EGPWS Mode 3 registered a too high sink rate at too low an altitude when the helicopter's indicated airspeed passed 50 kts, and issued the warning: '*Don't sink, don't sink – CAUTION'* for five seconds; see Figure 12. Immediately afterwards, Mode 2B issued the warning *'Terrain, terrain – CAUTION'* for one second, followed by *'WARNING terrain, WARNING terrain, WARNING terrain'* for six seconds. This indicated that the flight profile would result in the helicopter crashing into the sea unless corrections were made.

A new standard for the Helicopter Terrain Awareness and Warning System (HTAWS) (ED-285/DO-376) was published in 2021.

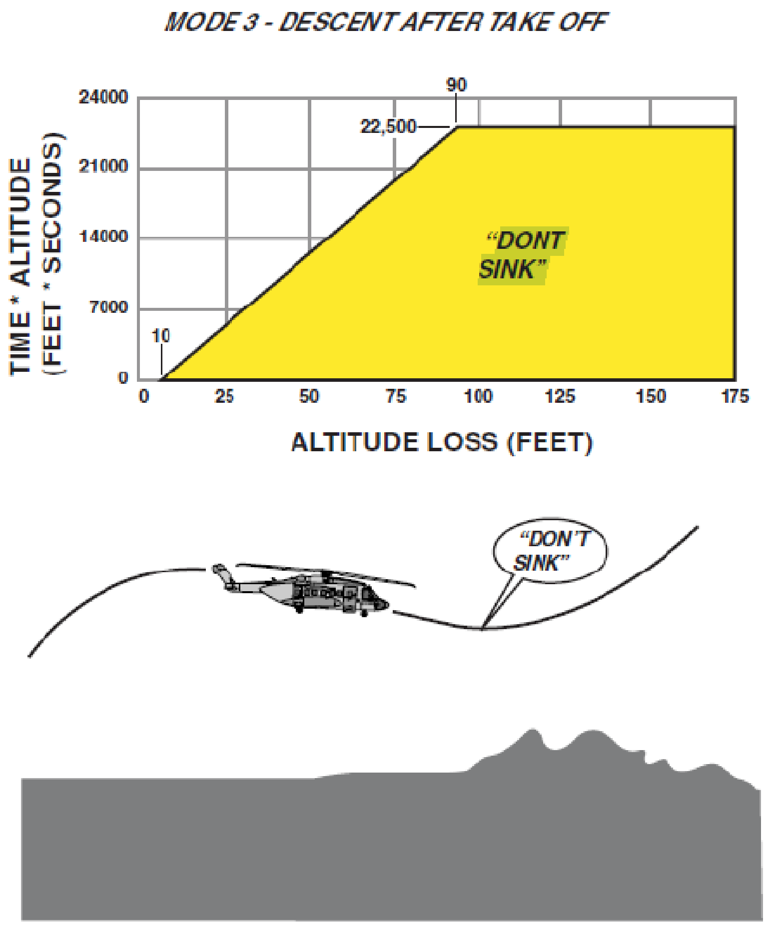

Figure 12: EGPWS mode 3 as activated in the present incident. Illustration: Bristow/NSIA

1.6.5 AUTOPILOT

The Sikorsky S-92A is equipped with a standard Hamilton double digital automatic flight control system (AFCS). The autopilot keeps the helicopter stable around the vertical (yaw), longitudinal (roll) and lateral (pitch) axes. It makes it possible to fly a helicopter without the pilot having to keep his hands on the controls or his feet on the pedals.

The cyclic stick is connected to electromagnetic brakes and trim springs. When the pilot presses the cyclic force trim release button, and then moves the cyclic, the cyclic gets a new reference point for the helicopter's roll and pitch attitude when the button is released again; see Figure 13. This means that if the pilot then removes his hand from the cyclic, it will return to the new refence point.

If the autopilot is in airspeed mode, the new reference speed will be the helicopter's speed when the pilot releases the cyclic force trim release button.

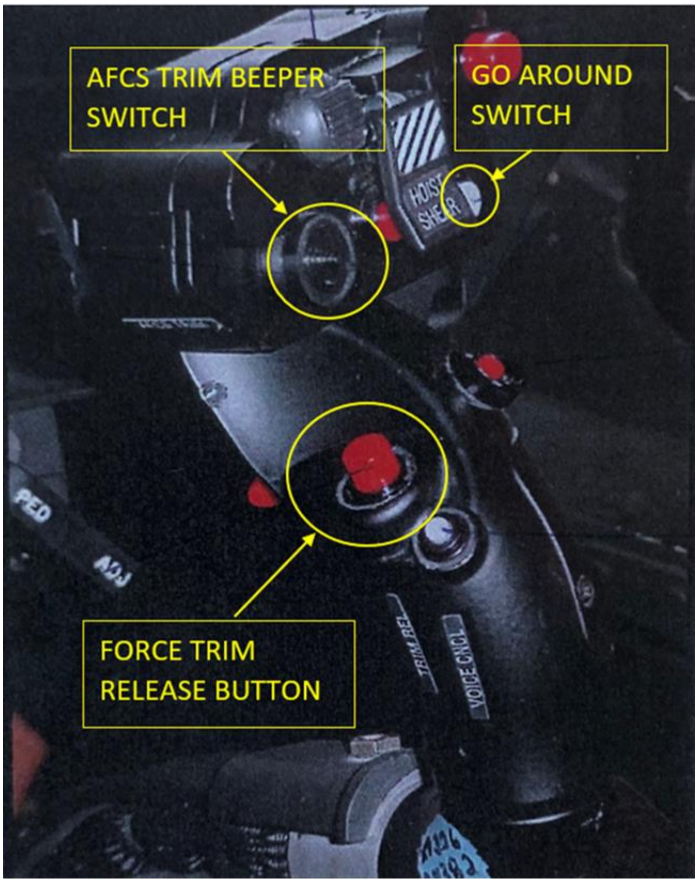

Figure 13: The S-92A's cyclic stick has a number of switches and buttons with different functions, including the force trim release button, the AFCS trim beeper switch and the go around switch. Photo: Sikorsky S-92A Pilot Training Manual / NSIA

The same applies to the collective, which also has a force trim release button; see Figure 14. In the moment that the pilot presses the button, selects the desired climb power for the take-off and releases the button again, this will be the new reference point to which the collective will return if the pilot takes his hand off the collective.

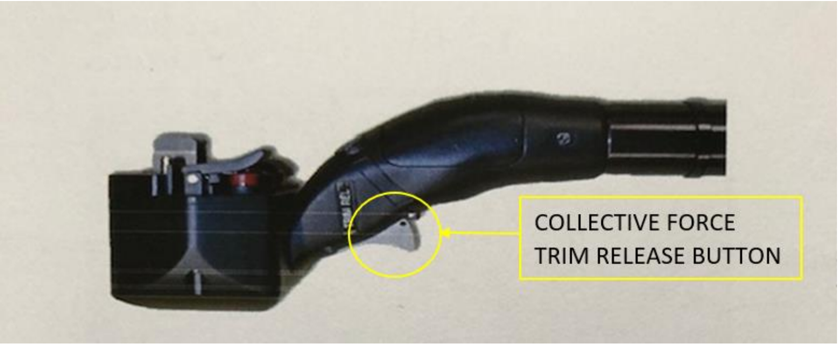

Figure 14: Collective with collective force trim release button. Photo: S-92 Pilot Training Manua l/ NSIA

The AFCS has two regimes for directional stabilisation. Below 50 KIAS the SAS YAW has a heading hold and gust alleviation when not pressing the microswitches. Above 50 KIAS it changes to turn coordination. The pedals used for coordinated turns are equipped with yaw trim release microswitches; see Figure 15. These are activated when the pilot steps on the pedals, and by changing the position of the pedals and then removing his feet, the pilot sets a new reference point for directional control. The helicopter can only be flown with a coordinated turn function, or be trimmed around the yaw axis, if the indicated airspeed exceeds 50 kts. At lower speeds, it is the pilot's pedal action that controls the helicopter's heading as long as he keeps his feet on the pedals and the microswitches are activated.

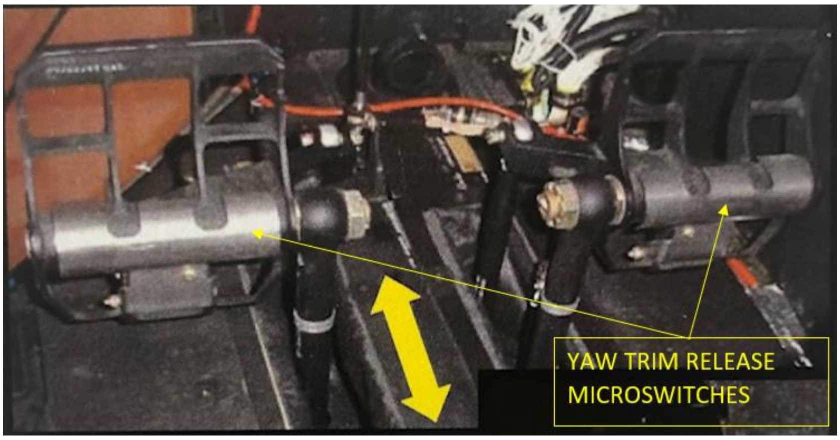

Figure 15: The pedals in the S-92 with yaw trim release microswitches behind the bright covers on which the pilot places his feet. Photo: S-92 Pilot Training Manual/NSIA.

The autopilot in the S-92A is designed with 50 kts as the minimum indicated airspeed for engaging the autopilot's airspeed mode, altitude mode, heading, altitude preselect and vertical speed.

After take-off from Maersk Invincible, LN-ONT accelerated to an indicated airspeed of 28 kts before the high nose-up pitch caused the speed to drop to zero. The helicopter drifted leftwards and started to accelerate rearwards. The helicopter did not reach the minimum speed for engaging the autopilot modes (V-min) until the commander took over the flight controls, initiated a descend and accelerated the helicopter through and beyond 50 kt.

1.6.6 SERVO ACTUATORS

The Sikorsky S-92A is equipped with four electro-mechanical actuators, mounted in the cockpit ceiling. These are trim actuators that provide reference points and an artificial control gradient for all the flight controls. When the helicopter is trimmed and in balance, the actuators will hold the flight controls so that the pilot has his hands free. If the flight controls are moved without the force trim release button being activated, the actuators will supply a force that increases resistance. The flight controls will also seek to return to their reference points if released.

Each actuator has full control authority, which means they can move the flight controls from one end to the other along each axis. Their movement is limited to 10% per second. The trim actuators are roughly adjusted using the force trim release button, and then fine-tuned using the four-way AFCS trim beeper switch on the cyclic.

1.6.7 GO-AROUND MODE

The helicopter's autopilot also has a go-around (GA) mode. According to the S-92A Flight Safety International Pilot Training Manual the GA mode was originally designed to enable transition to stable climb-out based on known flight parameters in the following situations:

- After a missed IFR approach
- Upset prevention and recovery (UPR)

GA mode is activated by the pilot pressing a switch on the cyclic; see Figure 13. The S-92A's pilot training manual states that, if this mode is activated, the autopilot is pre-programmed to stabilize the helicopter at a horizontal attitude around the longitudinal axis, and to establish a rate of climb of 750 ft/min with an indicated airspeed of 80 kts. The helicopter will maintain the heading it has when GA mode is activated, until it is adjusted by the pilot using the autopilot's heading mode. The helicopter will climb until it possibly reaches a defined flight height.

S-92A helicopters must have an indicated airspeed of at least 50 kts before GA mode can be activated. GA mode was not activated during take-off from Maersk Invincible.

The helicopter manufacturer published Supplement 45 on 31 July 2019 to the flight manual where operational limitations and best practices for using GA mode are described. There it appears that the intention behind GA mode was to be able to abort an approach and establish a stable climb to known parameters by pressing the GA switch. At the same time, it is emphasized that if the function is used in connection with take-off, it is of vital importance that the flight controls are trimmed and are without resistance. If the resistance in the flight controls is not trimmed out, it can result in abnormal nose up/down attitude. It is also specified that GA mode should not be used during take-off.

According to the supplement, if the function is still used during take-off the best practice for engaging GA mode is the following:

- After the Category “A” or Category “B” departure is complete.
- Only after the aircraft is in a stable climb at or above Vy and clear of all obstacles.
- Above 1000 feet AGL.

1.6.8 FLIGHT DIRECTOR LOW SPEED MODES

There are two different versions of Flight Director (FD) Modes for S-92A, Basic FD Modes and FD SAR Modes. Helicopters transporting passengers are equipped with the first one only, while the SAR version of the helicopter type has both.

In addition, there is an upgrade of the autopilot called Rig Approach System. This upgrade is available for both SAR helicopters and passenger helicopters. Rig Approach System allows you to fly with the autopilot engaged at speeds below 50 kt.

The purpose of Rig Approach Modes is to enable GPS approaches where the autopilot ensures that the helicopter follows a predefined approach profile and adjusts airspeed and altitude down to a pre-programmed point close to the oil installation. From this point, the pilot must take over the flight controls and then land the helicopter manually.

Rig Approach Mode includes the Departure (DPT) feature. DPT engages a predefined climb and acceleration from hover. DPT is engaged by the pilot by pushing the DPT/GA switch on the cyclic. DPT may also be engaged by the pilot not at the flight controls by selecting the DPT function key on the SAR APP 2 or SAR HOV page on the mode select panel.

The pilot sets the collective to take off, accelerates vertically to the TDP, lowers the nose of the helicopter, and starts an acceleration away from the helicopter deck. The pilot then trims out the forces in the flight controls and activates the DPT / GA switch. Low indicated airspeed (<50 kts) and no weight on wheels are the criteria for activating DPT mode.

If the switch is activated, the DPT mode will ensure that the helicopter automatically climbs out wings level and accelerates to 65 kts at a rate of 2.5 kts per second. At an indicated airspeed of 65 kts, the autopilot engages GA mode, and the helicopter continues to increase the airspeed to 80 kts and establishes a steady rate of climb of 750 ft/min. Consequently, the autopilot can be activated during departure from a helicopter deck as described in Supplement 36 in the flight manual: Category ‘B / Elevated Helideck Takeoff.

Like other S-92As used for passenger transport on the Norwegian continental shelf LN-ONT was not equipped with Rig Approach or Departure Mode functions.

The NSIA has been informed that of four S-92A simulators, three of them are equipped with Rig Approach or Departure Mode, one in Aberdeen, one at Sola and one at West Palm Beach in Florida, USA. The crew performed their simulator training on Sola.

1.7 Weather

1.7.1 WEATHER INFORMATION FROM EKOFISK ATIS

Wind from 100° 37 kts, visibility 5 km, rain and mist – RABR, clouds SCT007 BKN009, temperature + 3 °C, dewpoint + 2 °C and atmospheric pressure QNH 988 hPa.

METAR ENLE at 19:50Z, wind speed 38 kt from 090°, visibility 5,000 m in rain and mist, cloud cover BKN at 800 ft, temperature + 3 °C, dewpoint + 3 °C, atmospheric pressure QNH 985 hPa, sea temperature + 8 °C and wave height 'Sea State' 5 m.

1.7.2 WEATHER INFORMATION – HELIDECK REPORT

The following weather information was provided in the helideck report: Wind speed 42 kts with gusts of 47 kts from 120°, visibility 7,000 m and clouds BKN at 900 ft. Temperature + 3 °C, dewpoint + 1.8 °C and atmospheric pressure QNH 993 hPa. The crew received updated weather information approx. 20 minutes before landing. The weather had then changed to the following: Wind 33 kt from 118°, visibility 3,500 m, Overcast in 600 ft and atmospheric pressure QNH 988 hPa.

1.8 Aids to navigation

Flight Management System (FMS) and Maersk Invincible NDB 534.

1.9 Communications

Two-way communication with Maersk Invincible at 118,050 MHz and the Helicopter Liaison Officer (HLO) at 130,550 MHz, and with Ekofisk Log at 118,050 MHz, Ekofisk Helicopter Flight Information Service (HFIS) at 130,550 MHz and subsequently Norway Control at 125,875 MHz.

1.10 Helideck

Maersk Invincible is a jack-up rig. Since the entire oil installation can be raised and lowered, the height of the helicopter deck above sea level may vary. At the time of take-off from Maersk Invincible, the height of the helideck was 78.9 metres (258.10 ft); see the helideck report. The helideck had an orientation of 136°, a D value[6] of 22.8 and a maximum permitted weight of 34,361 lbs. Maersk Invincible was connected to Valhall.

1.11 Flight recorders

LN-ONT was equipped with a Curtiss-Wright combined voice and flight data recorder (CVFDR) with part number D51615-142 and serial number SNA04861-001.

The cockpit voice recorder (CVR) was able to record the past two hours of radio transmissions, announcements to passengers, ambient noise via the microphones and communication between the pilots. The audio files that were downloaded were of good quality.

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[6] The D value indicates the size of the helideck.

The FDR can store the last 25 hours of flight data. Stored data include rotor and engine speeds, airspeed, the helicopter's altitude, heading, inclination and the movements of the flight controls.

The unit was removed and secured on the same day as the incident occurred. The data were downloaded to a memory stick[7] that was handed over to the NSIA. L3 Harris Technology UK (formerly Flight Data Services UK) assisted the NSIA in producing a 3D animation of the incident, based on the CVFDR data.

1.12 The helicopter

As far as the NSIA has been able to ascertain, LN-ONT was certified and equipped in accordance with existing regulations. The NSIA found no indication of any technical faults in the systems before or during the incident. The crew has informed that they experienced no technical errors that contributed to the incident.

Mass and balance calculations showed that the helicopter was within the limitations.

Bristow Norway AS inspected and conducted a test flight with the helicopter after the incident, without finding any nonconformities. The helicopter was subsequently returned to ordinary operation.

1.13 Medical and pathological information

No medical or health issues have emerged that could have affected the crew during the flight. The crew had been awake from approx. 0700 in the morning and made one flight to the Gyda oil installation between Ula and Ekofisk earlier the same day.

1.14 Fire

Not relevant.

1.15 Survival aspects

The helicopter was fitted with buoyancy equipment certified for ditching in wave heights of up to 4–6 metres; Sea State 6. All passengers and crew were wearing immersion suits with breathing system and buoyancy vests.

1.16 Tests and research

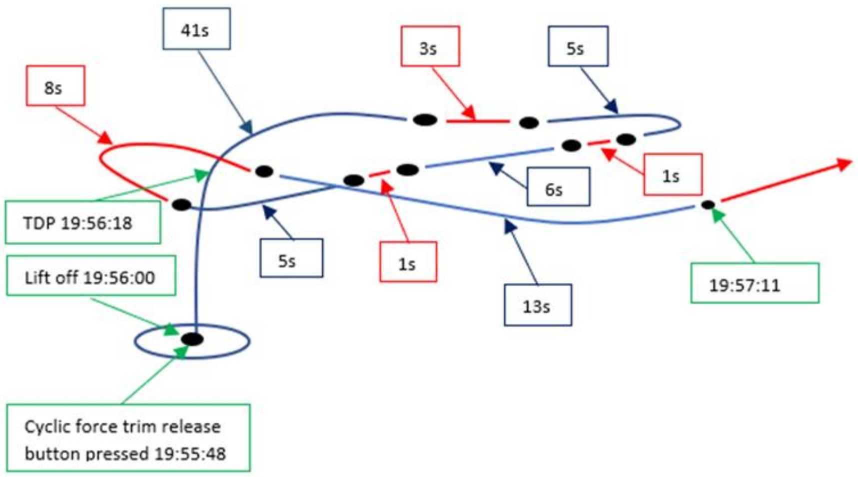
1.16.1 USE OF THE CYCLIC FORCE TRIM RELEASE BUTTON

When the pilot presses the cyclic force trim release button, and then moves cyclic, cyclic is given a new reference point for the helicopter's position around the longitudinal axis and transverse axis (roll and pitch) when the button is released again.

Data from the flight data recorder show that the cyclic force trim release button was depressed (activated) and released (deactivated) five times during the take-off. The cyclic received new reference data five times during 1 minute and 23 seconds. The FDR data do not indicate which side in the cockpit the cyclic force trim release button was operated from.

[7] *The operator reported that it had no spare CVFDR available as the reason for downloading the data to a memory stick.*

The crew has informed the NSIA that the cyclic force trim release button was last activated when the commander took over the flight controls. The button was depressed for 13 seconds and deactivated at 19:57:11; TDP + 53 seconds, after a steady climb and airspeed had been established, see Figure 16. Note that all times in this section is UTC times (local time -1 hour).



19:55:48 'Activated'
19:56:00 (The first officer brings the helicopter into hover)
19:56:18 (The captain calls TDP)
19:56:29 'Deactivated'
19:56:32 'Activated'
19:56:37 'Deactivated'
19:56:38 'Activated'
19:56:44 'Deactivated'
19:56:45 'Activated'
19:56:50 'Deactivated'
19:56:58 'Activated'
19:57:11 'Deactivated'

Figure 16: The departure profile and timeline for the five times the cyclic force trim release button was activated (in blue) and deactivated (in red). The illustration is not to scale. Source: LN-ONT CVFDR/NSIA.

1.17 Organisational and management information

1.17.1 BRISTOW NORWAY AS

At the time of the incident, Bristow Norway had 427 employees. The company operated 25 Sikorsky S-92A type helicopters, and its administration and operational base was at Stavanger Airport Sola. In 2016, Statoil (now Equinor) had awarded Bristow Norway new contracts for transporting oil workers to/from Bergen Airport Flesland and Florø Airport.

1.17.2 THE HELICOPTER OPERATOR'S PROCEDURES (OMA/OMB)

Bristow Norway has many years' of experience as a national and international offshore flights operator. It has established a set of procedures for its helicopter operations. Appendix B contains excerpts from the most important incident-related procedures in Operations Manual A – OMA and Operations Manual B – OMB. According to the operator, the list of deviation calls[8] in OMA section 8.3.23.3, reproduced in Appendix B, is based on industry standards.

1.17.3 FLIGHT DATA MONITORING (FDM)

As part of its safety management system (SMS), the helicopter operator has established its own flight data monitoring (FDM) programme. FDM is mandatory and is described in ICAO Annex 6 part 1 and EU – OPS 1.037, among other places. FDM is also a recommended requirement in 066 – Norwegian Oil and Gas Recommended guidelines for flights to petroleum facilities. Bristow has informed the NSIA that the purpose of the programme is to monitor trends, and to identify any exceedances of pre-defined parameters during flights. The data are analysed on a regular basis and enable the operator to focus his attention on threats to aviation safety in all operations. Hence, corrective action can be taken before undesirable incidents occur. Among other things, the information is used to improve simulator training programmes and procedures. FDM is based on the Just Culture principle.

[8] Deviation calls, in this case between the pilots, are used to indicate uncommon situations.

Bristow Norway AS describes Just Culture in the following way: Just Culture is a concept related to systems thinking which emphasises that mistakes are generally a product of faulty organisational cultures, rather than solely brought about by the person or persons directly involved. Justness and accountability are important elements in this context, which, in turn, means that all employees shall be justly treated, and not be subjected to inappropriate disciplinary action after having been involved in cases with a bearing on safety. It entails that employees and others are not punished for actions, omissions or decisions taken by them that are commensurate with their experience and training, while gross negligence, wilful violations and destructive acts are not tolerated. (Source: Bristow Norway AS – Management System).

After the incident, the helicopter operator downloaded and analysed the FDM data from the relevant flight. The NSIA later went through the data together with the helicopter operator.

1.17.4 SIMULATOR TRAINING

Simulator training is mandatory and gives helicopter crews an opportunity to practise different manoeuvres and emergency procedures that cannot normally be carried out on real flights. By practising such manoeuvres under guidance in controlled and safe surroundings, the crew can learn to recognise different situations and thereby to handle such situations should they arise during a flight.

Bristow Norway's pilots regularly receive simulator training. Parts of the training include landing on and taking off from different types of oil facilities, both fixed and movable units, in various simulated weather conditions in both daylight and at night-time.

Bristow Norway has stated that there was no standard procedure for use of the cyclic force trim release button at the time of the incident. It was up to the individual pilot to choose the technique he considered best. This was also the case during simulator training. The NSIA has been informed that the technique preferred by most pilots in connection with take-off from a helideck was to depress the button before bringing the helicopter into a hover, and to not release it until stable climb parameters had been established. An alternative technique used was to release the button when the correct pitch-up attitude had been established for the climb, and then make finer adjustments using the AFCS trim beeper switch on the cyclic.

Bristow Norway has informed the NSIA that the crew's scheduled simulator training programme includes upset prevention and recovery training (UPRT[9]) and training in how to handle pilot incapacitation, i.e. a situation where one of the pilots is unable to fly. UPRT training has special focus on helideck take-offs.

During the helicopter operator's proficiency checks and regular simulator training with Sikorsky S-92A, the pilots are instructed in the following procedure for recovering from unusual helicopter attitudes; see section 1.18.3:

- Establish a horizontal attitude (wings-level, roll attitude).
- Point the helicopter's nose towards the horizon or just above (2–3° pitch-up).
- Adjust the collective to make corrections for loss of altitude or to climb to a safe altitude and establish correct airspeed according to the situation.

The Federal Aviation Administration (FAA) has informed the NSIA that in 2017 the United States Helicopter Safety Team (USHST) established a working group to implement Helicopter Safety Enhancement (H-SE) 127A. The purpose was to analyse and develop training techniques for

[9] Upset prevention and recovery training (UPRT) is training in how to correct unusual attitudes around the roll, pitch or yaw axes or any combination of the three.

recognizing disorientation and techniques for how the aircraft's incorrect attitude can be corrected. (Recommended Practice: Spatial Disorientation induced by a Degraded Visual Environment (DVE) – Training and Decision-Making Solutions). The working group finalized the document on 9 December 2020.

1.17.5 CREW RESOURCE MANAGEMENT (CRM)

1.17.5.1 General information

Crew resource management (CRM) includes elements such as getting along with other crew members, knowing when and how to assert oneself effectively in critical situations, and maintaining situational awareness[10] (Martinussen & Hunter, 2008).

Requirements for CRM training follow from Annex III *Organisation requirements for air operations* (Part-ORO) subpart FC Flight Crew to Commission Regulation (EU) 965/2012 laying down technical requirements and administrative procedures related to air operations. Aircrew are required to complete the operator's basic CRM training as specified in the operations manual approved by the aviation authority. The CRM training shall be conducted by an approved instructor. Elements of CRM shall also be included in the continuing and refresher training of the crew.

EASAs Annex II to Executive Director (ED) Decision 2015/022/R describes Acceptable Means of Compliance/Guidance Material (AMC/GM) to Part-ORO. The CRM training shall include the following elements: human factors in aviation, general training in the principles and objectives of CRM, human performance and limitations, and threat and error management (TEM); see section 1.17.5.4.

In December 2017, EASA published a document[11] that provides further recommendations and information about CRM in practice:

> *'Crew Resource Management (CRM) training encompasses a wide range of knowledge, skills and attitudes including automation management, monitoring and intervention, resilience development, surprise and startle effect management, safety culture and cultural differences; together with all the human dimensions which each of these areas entails.*
>
> *CRM can be defined as a management system, which makes optimum use of all available resources (equipment, procedures and people) to promote safety and enhance the efficiency of flight operations.*
>
> *CRM training improves the cognitive and interpersonal skills needed to manage the flight. In this context, cognitive skills are defined as the mental processes used for gaining and maintaining situational awareness, for solving problems and for making decisions. Interpersonal skills include communication and a range of behavioural activities associated with teamwork. These skill areas often overlap with each other, and they also overlap with the required technical skills.'*

1.17.5.2 The helicopter operator's CRM training programme

Bristow Norway has established a CRM training programme for new recruits and a CRM training programme for refresher training. The programmes and the operator's requirements for both

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[10] Situational awareness (SA) is defined as follows: Situational awareness is the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and a projection of their status in the near future (Endsley, 1995, p. 36).
[11] EASA (2017): CRM Training Implementation. Available at https://www.easa.europa.eu/document-library/general-publications/crm-training-implementation (Downloaded 29 October 2021).

training and refresher training are described in Operations Manual D based on AMC.ORO.FC.115 & 215, ORO.FC.230 (e) (2) and ICAO Doc 9995 *Manual of Evidence Based Training*.

The training is intended to reflect the operator's safety culture and shall consist of theoretical classroom instruction and practical exercises and group discussions as well as a review of serious aviation incidents and the lessons that can be learnt from them.

The objective is to improve the crew's communication and leadership skills. The emphasis is mainly non-technical, focusing on human aspects during different phases of a flight.

1.17.5.3 The two-challenge rule and handover of flight controls

The helicopter operator has described procedures for communicating deviations from the standard profile by using deviation calls in OMA section 8.3.23.3 – communication procedures for taking over the flight controls and the importance of doing so early in connection with disorientation; see Appendix B. The procedures have been developed and adopted as a tool for the pilots and are, together with what is known as the two-challenge rule, intended to enable detection of any incapacity on the part of the PF and ensure an as-safe-as-possible transfer of the flight controls to the PM.

The two-challenge rule entails that a crew member assumes the tasks and duties of another who fails to reply to two consecutive verbal challenges. The challenges take the form of standard deviation calls to inform of deviations from defined flight parameters and the need to make corrections. If the PF fails to respond to a deviation call twice, the PM shall assume control of the helicopter and continue the flight by stating 'I have control'.

The PF has a corresponding responsibility to notify of any wish to hand over the controls to the PM by stating 'You have control' should any of the above-mentioned circumstances arise.

1.17.5.4 Threat and error management (TEM)

The concept of threat and error management (TEM) was introduced in the 1990s. In practice, TEM entails reviewing upcoming tasks in advance to identify possible safety challenges, and then find compensatory actions to reduce the consequences should the identified challenges actually occur. It is a fundamental assumption in TEM that threats and errors will occur, and that they must therefore be identified and handled (EASA, 2017).

EASA Part FCL[12] and the International Civil Aviation Organization (ICAO) require the inclusion of human factors and TEM in all pilot training. All pilots, from students to professionals, shall demonstrate attitudes and behaviour commensurate with the safe performance of flights, including the ability to recognise and handle potential threats and errors.

The European Helicopter Safety Team (EHEST) has studied the recommendations made after a number of serious aviation incidents in order to assess and document the need for TEM training. The study data confirmed that a significant number of helicopter accidents occur as a result of poor judgement and human performance both in connection with pre-flight planning and during flights.

In December 2014, EHEST published Leaflet HE 8 'The Principles of Threat and Error Management for Helicopter Pilots, Instructors and Training Organisations'. The leaflet was intended to introduce flight crew and training organisations to the concept of TEM.

The TEM training was structured and designed to meet competence standards so that the training organisations could develop their own methods of TEM instruction. It also gave inspectors

[12] *Flight Crew Licencing*

responsible for the renewal of aviation certificates improved guidelines for developing good methods of assessing pilots' TEM skills.

At the time of the aviation incident, TEM procedures were included in Bristow Norway's governing operations documents. The concept was specified in the Expanded Checklist in the Operations Manual Part B. TEM was also part of the regular simulator training.

1.18 Additional information

1.18.1 SPATIAL DISORIENTATION AND SENSORY ILLUSIONS

The human sensory system consists of the visual system (sight), the vestibular system (organ of balance) and the somatosensory system (skin, joint and muscle senses). These systems are adapted to life on the Earth's surface. Under the special force and movement conditions that prevail in an airplane or helicopter, the senses can under some conditions provide information to the pilot that gives an incorrect picture of the situation. This is called spatial disorientation (Gibb, et al., 2016).

The vestibular system can illustrate how man's adaptation to conditions on earth can sometimes create spatial disorientation in a plane. The vestibular system is calibrated to interpret gravity as a reference for what is down and what is up. Gravity acts downwards towards the centre of the earth with an almost constant force everywhere on the surface. When an aviator is in an aircraft that is accelerating, the aviator will be pushed against the seat back. The combination of this force and gravity is perceived by the pilot as one resultant force. The resultant force will not act straight down like gravity, but downward and backwards. When the plane accelerates, the pilot will thereby get the feeling of being tilted backwards and that the nose of the plane is pointing more upwards than is the case.

There are many conditions that can lead to spatial disorientation. In the research literature they are often classified into different types of sensory illusions. The illusion described above is called the somatogravic illusion (Ref. NSIA reports SL 2019/10 and 2016/11) and usually occurs only when the aviator has limited visual references (Gradwell & Rainford, 2016). When the aviator has good visual references, the visual system will usually correct signals from the vestibular system so that the illusion does not occur. Spatial disorientation can happen to all pilots and occurs more frequently when flying in bad weather or at night, due to the fact that external visual reference will then be limited.

1.18.2 STRESS

Threat-based stress can affect a pilots cockpit performance, and how we handle the stress can be just as important as how we handle the threat. According to the FAA's Pilots Handbook of Aeronautical Knowledge (FAA-H-8083-25B), "*stress is the body's response to physical and psychological demands placed upon it. Examples of stressors include physical stress (noise or vibration), physiological stress (fatigue), and psychological stress such as difficult work or personal situations.*"

Stress falls into two broad categories: acute (short term) and chronic (long term). Acute stress involves an immediate threat that is percieved as danger. This type of stress triggers a "fight or flight" response in an individual, whether the threat is real or imagined.

Stress is a normal response to threats, with both physiological and cognitive aspects. Stress can affect pilots' mental performance in several ways. When we encounter a challenging situation, we automatically orient our attention to the situation, assess the nature and degree of threat, and mobilize our mental resources to respond. If we assess the situation as difficult but are confident we can manage it, our performance typically improves. But if we are uncertain we can manage a potentially harmful threat, anxiety may arise and undercut our normal cognitive processes and impair our performance in two fundamental ways that can undermine more complex aspects of a pilot's mental performance.

Stress is often ranked as the most limiting factor in terms of human performance. Being stressed can be critical to how a pilot handles a situation especially when the stress occurs quickly and unexpectedly.

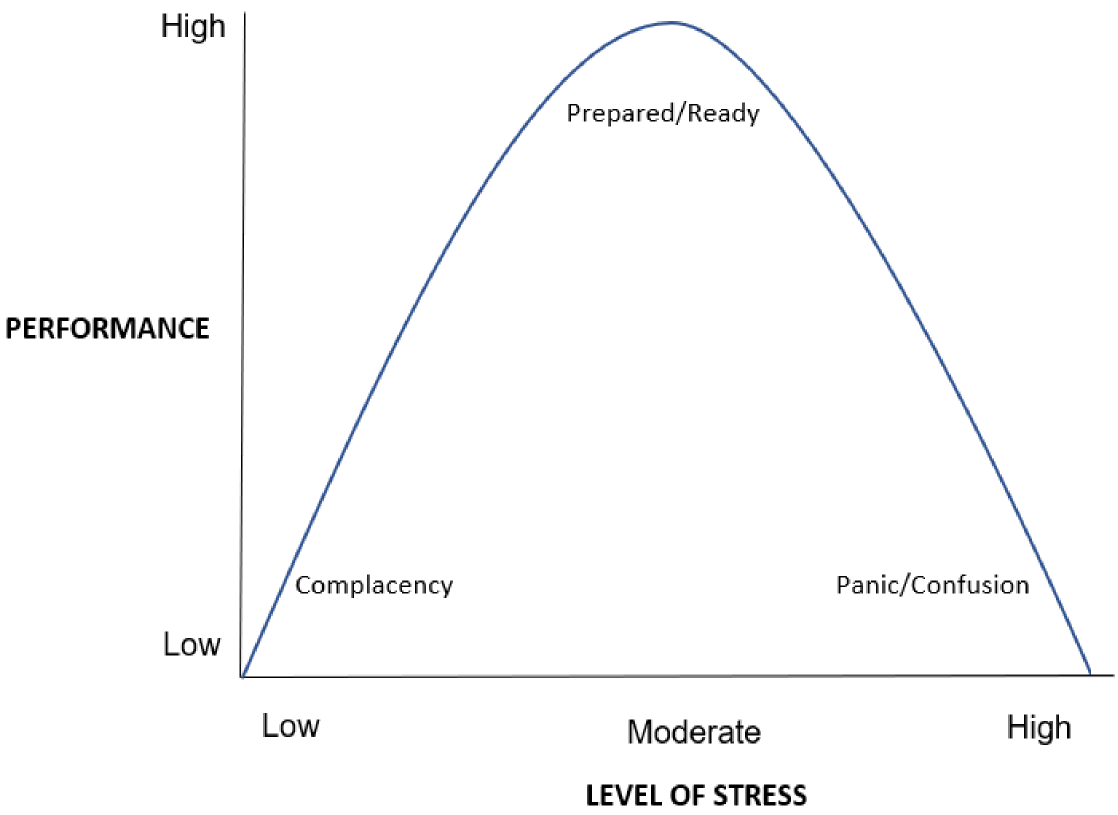

Figure 17: Typical stress / performance curve. Illustration: International Safety Institute / NSIA

If the pilot is exposed to high stress, the short-term memory is also affected, which is gradually reduced. If the stress level persists, the result is tunnel vision, reduced hearing and total blocking of the ability to perceive when the level passes the top of the stress curve. If the short-term memory stops working due to stress, no questions will be sent to the long-term memory and no answers will be produced. Then the ability to perceive is put out of function and the human performance ability is blocked.

The helicopter crews at Bristow undergo regular simulator training where coping with stress is an important part of the training.

Data from the helicopter's voice recorder (CVR) showed that the crew on LN-ONT was exposed to high acute stress levels during the period when the helicopter accelerated backwards and was out of control.

1.18.3 CORRECTING THE HELICOPTER'S INCORRECT ATTITUDE

In connection with offshore helicopter flights, the take-off phase from a helideck on an oil rig or ship is particularly challenging and thus associated with increased risk. This is even more true under conditions of reduced visibility, heavy rain or a low cloud base, because the transition from visual to instrument flight can result in disorientation and subsequent control problems, which may in turn result in an unusual attitude.

This was mentioned in a book published by the Federal Aviation Administration (FAA) in 2012. The following is quoted from that book:

> *In order to counteract this, three skills are particularly important to maintaining control of the helicopter during instrument flying:*
>
> *Instrument cross-check*
>
> *Correct instrument interpretation*
>
> *Positive control of the helicopter*
>
> *A breakdown of any one of these skills could result in an unusual attitude.*
>
> *Unusual attitudes can be caused by any one or a combination of factors such as turbulence, disorientation, instrument failure, confusion, preoccupation with flight deck duties, carelessness in cross-checking, errors in instrument interpretation, incapacitation or stress. Given the inherent instability of helicopters, unusual attitudes represent a significant risk for helicopter flight crews and passengers. As a result, it is critical that timely action be taken to recover the helicopter to a safe regime of flight as soon as possible with minimum loss of altitude.*
>
> *When attempting to recover from an unusual attitude, it is vital that pilots do not become fixated on a single instrument. In many cases, fixation occurs when the information does not match a person's mental model at that moment. In those instances, the pilot can become fixated while attempting to interpret the information that is in conflict with his understanding of the situation. Fixation on a single flight instrument, to the exclusion of other flight instruments, usually results in poor aircraft control. As a result, pilots must continue to cross-check all flight instruments while attempting to recover from an unusual attitude (FAA, 2012).*

According to the FAA's Instrument Flying Handbook, the procedure for recovering from an unusual attitude is to first correct the helicopter's bank, then correct its pitch and finally adjust the power as necessary.

1.18.4 SIMILAR AVIATION INCIDENTS WITH S-92A HELICOPTERS

9 December 2016: Unintended descent during night-time take-off from an offshore helideck

The following is quoted from the internal report:

> *After filling fuel and reassessing the weather conditions, the pilots decided to take off from the oil rig and continue the passenger flight between several oil rigs with a new alternative landing site ashore. Night-time conditions prevailed, with no visual horizon, a cloud base of 600 ft and visibility <10 km. The first officer in the left-hand seat had the role of PF. A standard take-off briefing for helideck departures was conducted, and a flight altitude of 400 ft was chosen to ensure sufficient distance to the clouds. Shortly after take-off, when the helicopter had climbed to 300 ft, the PM called "100 ft to go" and asked the PF whether he wanted to connect the autopilot. During the seconds that followed, the PF shifted his attention from the flight instruments to the autopilot mode selector panel. The helicopter started to descend rapidly from 300 ft. The PM called "check descending" before taking over the flight controls, correcting the flight profile and restoring a steady climb to 500 ft. He then asked the first officer to engage the autopilot. When the helicopter had been stabilised at cruising altitude 500 ft, the flight controls were handed back to the first officer.*

The following is an excerpt from the conclusions of the internal investigation:

It is clear that shuttle flights offshore night VMC is challenging, especially when weather situations equivalent to this event is a contributing factor, the crucial part is then a good plan and pre take off brief focusing on eventualities. In this case lifting off a helideck with a deck height approximately 250`and a level off at 400`is limited on time.

The crew pre take off / lift off brief should contain elements of threat and error management.

OMA 4.5.11 and 4.5.11.2 has a potential of enforcement even though it contains elements of risk control. Furthermore, the training department should engage to make sure that training including OPC`s pay particular attention to crew brief and specifically 4.5.11.2 final bullet point:

A briefing of elements in the take-off from Helideck which require a special attention or crew coordination effort in order to reduce risk exposure. (Obstructions, wind condition, or when special attention to manoeuvring or handling of the helicopter is required.)

27 November 2019: Unintended descent during take-off in the dark

The following is quoted from the internal report:

The take-off was performed with the first officer in the left-hand seat at the flight controls, in the dark without a visual horizon and with the oil rig's lit structures and visual references to the rear of the helicopter. A normal departure profile was flown to VTOSS and at a normal rate of climb. When the helicopter reached approximately 55 kts, the PF requested activation of ALT-P. At the same time, the PM noticed that a positive climb rate of 150 ft/min had changed to a horizontal flight profile and called "level flight". The PM momentarily shifted his attention to the autopilot mode selector panel, and when he raised his eyes again, he realised that the helicopter had started to lose altitude. This took place at just about the same time as the EGPWS issued the warning "Don't sink". The PM called "Pull up" at the very same moment as the PF restored a positive rate of climb. The crew thought they had descended approximately 50–70 ft before the helicopter was manoeuvred to a flight profile with a positive rate of climb. However, data from the flight recorder showed that the helicopter had a normal climb to approximately 200 ft before it started to descend, and that the lowest altitude before the deviation was corrected was 132 ft. The helicopter continued to climb and levelled out at a cruising altitude of 3,000 ft. The helideck had a height of 103 ft. The weather conditions: horizontal visibility >10 km, partly cloudy at 1,500 ft and a north-easterly wind of 32 kts, but no visual horizon.

The aviation incident resulted in the following internal recommendations on the part of the helicopter operator:

Similar event in 2016 had a recommendation to reflect on general threats during pre-takeoff and landing briefings described in OMA 4.5.11. The section is still considered vague with respect to so called Threat and Error Management. The investigation result reveals that the recommendation from 2016 should again be assessed. Take off briefs should contain elements of general threats that could affect a safe flight.

The same goes for Auto pilot couple strategy, also a safety recommendation similar event in 2016. Should again be assessed and checked if there still is weakness in procedures.

1.18.5 BRISTOW NORWAY – INTERNAL INVESTIGATION

Immediately after the incident involving LN-ONT, Bristow Norway initiated an internal investigation that was concluded on 23 July 2020.

Shortly after the incident, the investigation team interviewed the pilots involved and reviewed the FDR data and data from the Health and Usage Monitoring System (HUMS) and FDM.

The internal investigation team also wanted to listen to the cockpit voice recorder in order to better understand what had happened. In accordance with internal procedures, they asked for the pilots' consent to do so. The pilots did not consent to this, however. The content of the CVR was secured and subsequently handed over to the NSIA.

The internal investigation report indicated that the incident was caused by a combination of disorientation and overcorrection on the flight controls. This resulted in too high nose-up pitch and loss of speed, followed by loss of altitude until control was restored and a steady climb and speed were established.

The report also states that the pilots experienced a period of confusion combined with heavy workload until they regained control of the helicopter. According to the report, communication and standard phrases exchanged between the pilots did not work in an optimum manner during the incident and, for a while, the crew was uncertain who had the controls.

After the incident, both pilots were granted leave from active service and offered psychological consultation in accordance with the helicopter operator's procedures for following up serious aviation incidents. After a short period of leave, the pilots resumed their flight duties.

1.18.6 IMPLEMENTED MEASURES

After the aviation incident, the helicopter operator added the following best practice guidelines for use of the cyclic force trim release button in its Operations Manual B (OMB), reviewed by the Civil Aviation Authority Norway on 13 November 2020:

Bristow
Bristow Norway AS — OMB S92A MANUAL

2.2.11.2 Best practice of trim release

In all AFCS modes, pressing and holding the trim release button down releases pitch and roll stick forces allowing the pilot to move the cyclic stick with very little resistance. Once the pilot takes their thumb off the trim release button: the cyclic trim force is referenced to the new stick position plus the pitch and roll attitude at the time of button release is the new trimmed attitude.

Best practice for take offs and landings; Is to use the trim release function for setting new aircraft attitude. Once the aircraft attitude is set, adjustments of the aircraft attitude can be done by the means off the cyclic beeper. Power adjustments can be done by the means of the collective beeper.

As an example; After reaching TDP on an offshore day take off, rotate between 10-20° nose down using the trim release button. Once the attitude is set, release the trim release button and make required adjustments with the trim beeper.

Figure 18: Best practice guidelines for use of the cyclic force trim release button in OMB. Source: Bristow Norway AS

1.19 Useful and efficient investigation methods

No methods have been used during this investigation that qualify for special mention.

2. Analysis

2. Analysis

2.1 Introduction

Immediately after take-off from the Maersk Invincible (XMKI) oil rig located in the Valhall oil field, helicopter BHL 352 lost altitude and deviated significantly from a normal and steady departure profile. At reduced altitude, significantly below the level of the helideck the helicopter took off from, the crew regained control and established a controlled and steady climb-out. Control had then been lost for about 40 seconds. The course was then set towards the destination, Stavanger Airport, Sola.

After the incident, Bristow Norway inspected the helicopter for technical faults and conducted a test flight. The NSIA has examined data from the helicopter's combined voice and flight data recorder (CVFDR) and interviewed the crew. No findings of technical faults were found in the helicopter or any of its systems that contributed to the incident. Based on this, the analysis is primarily focused on operational factors that contributed to the serious aviation incident, as well as aspects of the helicopter's technical systems that may have affected the incident or the sequence of events. Organisational and procedural factors that could improve the safety of offshore helicopter flights are also discussed.

2.2 Manoeuvring of the helicopter after take-off

The oil rig's helideck report indicated a wind speed of 42 kts with gusts of 47 kts. Such strong winds normally lead to the formation of white caps on the waves. White caps can be used to the pilots' advantage as additional visual references when the visibility is poor and in conditions of darkness. However, it was not possible for the pilots to see any white caps before the helicopter left the helideck. This was probably due to a combination of darkness, heavy rain, and the height of the deck, which was 259 ft above sea level.

The helicopter's searchlight was positioned to throw the light straight forward. The NSIA does not rule out that the combination of headwinds exceeding 30 kts and heavy rain may have contributed to an illusion of forward speed during take-off. The searchlight's position during take-off may have made the rain streaming down the front windows all the more visible to the pilots.

A helicopter crew's assessment of the optimum searchlight position during take-off will most likely depend on two factors. Firstly, the searchlight can be directed to throw light on the helideck below to facilitate landing in the event of an aborted take-off. It is not unusual, however, to direct the searchlight forward at a slight downward angle, as that can be helpful in the case of engine failure at or just after TDP. This will probably enable the crew to see the surface of the sea and the white caps sooner than if the searchlight is positioned differently, thereby facilitating manoeuvring of the helicopter in an emergency situation.

Once the Offshore Pre-Takeoff Checklist had been completed, see Figure B1 in Appendix B, the first officer brought the helicopter into a 5-ft hover. The commander then carried out a hover check in accordance with the operator's procedures and the first officer confirmed that he was ready. The first officer then initiated a vertical climb towards TDP.

The commander explained that he felt that the helicopter moved slightly forward after the first officer had brought it into a hover. This led to difficulties for the commander to keep the helideck's edge lights in view as visual references in front of the helicopter. In such a situation with reduced visual references and the oil rig's lit-up structures to the rear of the helicopter, it would be natural to make sure that the helicopter does not move rearwards towards any obstructions in the vicinity of the helideck. For that reason and to place the helicopter in an optimum position for take-off, it is not uncommon to manoeuvre the helicopter carefully forward while hovering.

In accordance with standard procedures for best positioning in hover, the helicopter shall be brought into a hover so that the yellow circle on helideck is directly below the cockpit seats. The ideal take-off position is when the tip of the rotor disk is vertically above the edge of the helideck. This position minimises the risk of contact between the tail of the helicopter and the edge of the helideck in the event of engine failure at or just after TDP if take-off is continued.

However, in this case the helicopter was probably not lifted vertically into hover by the nose wheel being lifted first and then the main wheels, but that the cyclic position at the moment caused all the wheels being lifted off the helideck simultaneously and consequently the helicopter moved forward.

The S-92A is equipped with a four-way switch on the cyclic – AFCS trim beeper switch for fine-tuning the helicopter in pitch attitude; see 1.6.6. Using the AFCS trim beeper switch is not expedient in an early phase of take-off, however, since the authority to change pitch is too limited to ensure the desired rotation at TDP. Late rotation at TDP can delay horizontal acceleration to such an extent that loss of altitude in the event of engine failure can cause the tail of the helicopter to come into contact with the helideck.

During the take-off from Maersk Invincible, the crew lost control of the helicopter. Almost a minute passed before the crew regained control of the helicopter after take-off. A review of the CVFDR data shows that it took 34 seconds, measured from TDP, before the captain confirmed that he had taken over the controls and hence the manoeuvring of the helicopter.

Based on the CVR data the NSIA was able to determine that confusion and a lack of situational awareness prevailed during this period. The data also showed that in the same period there was high stress and a heavy workload for the crew while communication broke down.

The NSIA finds it probable that acute stress in this phase led to both impaired hearing and communication ability until control of the helicopter was regained and stable climb was established.

2.3 Use of the cyclic force trim release button

The departure from Maersk Invincible was flown manually by the first officer with the cyclic force trim release button activated. It was first activated approximately 12 seconds before the first officer called 'Go' and started the vertical acceleration towards TDP at 30 ft above the helideck. After 41 seconds, the button was deactivated for three seconds and then activated again for five seconds. During these five seconds, the helicopter reached its maximum pitch-up attitude, while yawing considerably to the right. At the same time, it drifted leftwards, away from the oil rig. Just after that, is started to accelerate rearwards. While the helicopter was accelerating rearwards at a high pitch-up attitude, the button was deactivated for one second, then activated again for six seconds, deactivated for another second and then activated for another five seconds. During the seconds that followed in the last phase of the rearward acceleration, while the helicopter adopted a pitch-down attitude, the button was released once more, this time for eight seconds. The crew were disorientated and not in control of the helicopter during this phase.

At that moment, the captain became aware of the lights from the oil rig on the helicopter's right-hand side, which was approaching from behind.

The NSIA believes that this significantly helped to increase the understanding of the situation and made him more capable of taking control of the flight. The commander then confirmed that he had the controls and initiated forward acceleration and descent by depressing the cyclic force trim release button for 13 seconds until a steady climb airspeed was established.

Once the airspeed, torque and pitch-up attitude for a steady climb-out were established, he let go of the cyclic force trim release button, thereby setting a new reference datum for the helicopter's normal climb attitude.

The NSIA believes that using the cyclic force trim release button to set four new reference datums for the helicopter's attitude may have caused some overcontrolling and thus made the situation worse. The way the cyclic force trim release button was used may also have extended the period during which the helicopter was out of control.

After the aviation incident, the helicopter operator has drawn up best practice guidelines for use of the trim release and included them in Operations Manual B. In the NSIA's opinion, follow-up of standard techniques through regular simulator training in best practice use of trim release can have the effect of an additional safety barrier in similar situations.

2.4 Blowback and the helicopter's aerodynamics

The helicopter's aerodynamic characteristics, whereby the airflow raised the forward part of the rotor disc during acceleration, may also have contributed to the helicopter's nose-up attitude. In combination with disorientation, it may have been challenging to apply forward cyclic, or trim the helicopter forward at the correct rate by using the AFCS trim beeper switch to compensate for the aerodynamically induced pitch-up.

2.5 The autopilot, departure, go-around mode and automation

The serious aviation incident occurred during take-off from the oil installation Maersk Invincible in the dark and in very challenging conditions where the crew had no external visual references. For a period of time the crew lost control of the helicopter. Control was lost before reaching the minimum speed for engaging the autopilot. The helicopter was not equipped with the Rig Approach System and therefore did not have a Departure mode. If the autopilot had a Departure mode it could have enabled the use of the autopilot to stabilize the helicopter from low speed.

Several unfortunate factors came into play. Departures of this nature are particularly demanding. One reason is that the helicopter itself must be seen as an unstable platform until it reaches a sufficient speed (V-min) for the autopilot to be engaged. For the relevant helicopter type in passenger configuration, V-min equals 50 kts indicated airspeed. Below this speed, the helicopter must be flown manually.

Chapter 1.6.8 describes the Flight Director Low Speed Mode upgrade for the relevant helicopter type. The NSIA considers the absence of this function in helicopters used for passenger transport to be a deficiency. A lower V-min throughout the departure phase would significantly improve safety, particularly when it comes to difficult helideck departures under conditions of darkness with reduced visibility, no visual horizon and if disorientation should occur. It would help to ensure that helicopters establish a steady climb to pre-defined flight parameters in the earliest possible phase after TDP and after a horizontal acceleration is initiated.

The NSIA initially assessed a safety recommendation that dealt with upgrading the helicopter type's autopilot to the SAC Rig Approach System for helicopters used in passenger transport in offshore flights. The Departure Mode is part of Low Speed Modes which can be used during departure from the helicopter deck as described by the helicopter manufacturer in Rotorcraft Flight Manual Supplement No. 36 Revision No. 2 for the helicopter type.

The proposal for a safety recommendation was previously sent out for external consultation. Feedback from several external entities of consultation shows that the view on the safety benefits of a comprehensive and expensive upgrade is divided. Therfore, the NSIA does not issue any safety recommendation, but maintains that an upgrade of the autopilot will provide a significant safety gain in conditions such as during this incident.

The new standard for Helicopter Terrain Awareness and Warning System (HTAWS) (ED-285/DO-376) was published in 2021.

2.6 Disorientation, sensory illusions and crew cooperation

The NSIA finds it likely that the crew's loss of situational awareness was triggered by spatial disorientation and that, together with other factors, resulted in loss of control of the helicopter during departure.

The first officer had only had one skill test (OPC) in the simulator after his type rating on the S-92A in May 2019. He had nevertheless flown approx. 84 hours in night-conditions on the helicopter type during the last 12 months and he had 11 night-landings on helicopter decks in the last 90 days. The NSIA cannot conclude that low experience on the helicopter type in question has had an impact on the aviation incident.

After TDP, the helicopter started an almost horizontal acceleration, but it did not climb as expected. Instead, it started to descend at a moderate rate of just over 100 ft/min. This was correctly observed by the commander who used the deviation call *'Level flight, we are descending, we are descending'* to get the first officer to correct the deviation and establish a steady controlled climb in addition to a smoothly increasing airspeed.

When interviewed, the first officer compared the experience with being in the flight simulator without getting a feeling of acceleration. During manual flying, when a helicopter is hovering or moving slowly, it is a platform where the pilot may have no physical experience of acceleration or directional stability because the acceleration is too slow for his body to register. Heavy rain and wind whipping against the cockpit windows that gives the illusion of forward speed does not make the task easier. When flying manually, a pilot is therefore completely dependent on being able to observe visual references outside the helicopter to maintain the helicopter's attitude.

During the seconds that followed, the helicopter accelerated to approximately 35 kts indicated airspeed at an altitude of 306 ft above the sea. The helicopter then developed a nose-up pitch of more than 25 degrees at a rate of 6.4 degrees per second. At the same time, the indicated horizontal airspeed dropped to zero. When the torque of both engines dropped to 66%, the commander called '*Power in, power in',* and the first officer increased the torque until it reached 88–89% again. At that moment, the helicopter yawed significantly to the right, from 103° to 155°, while drifting to the left, and then started to accelerate rearwards more than 20° nose-up for approximately 15 seconds while losing altitude.

The NSIA finds it probable that the helicopter's significant yaw to the right was a result of inadequate correction with the left pedal as the collective was increased. In helicopters like the S-92, correct pedal movement is absolutely necessary to keep the helicopter in trim with the ball in the centre for coordinated directional control as long as the feet are on the pedals so that the microswitches are activated. The unintended turn brought the helicopter sufficiently far away from the oil rig, however, to avoid the possibility of a crash during the rearward flight.

While the helicopter was accelerating rearwards and descending, the first officer struggled to regain control. Indications of changes in heading and increasing ground speed on the multi-functional display (MFD), while there was no indication of airspeed, may have added to the confusion. The ground speed indication is a satellite-based indication of speed. It shows the helicopter's speed over ground or sea regardless of which direction the helicopter is moving in and does not provide the pilots with any directional information. During this phase, the helicopter was moving rearwards over a total distance of approximately 210 metres and the ground speed increased to a maximum of 49 kts (90.748 km/h) before the nose-up attitude was corrected.

The NSIA believes it to be highly probable that the first officer had great difficulties understanding the information on the MFD because it was not what he expected to see. It is likely that, as a result of spatial disorientation, the first officer was unable to lower the helicopter nose and increase the collective soon enough to correct the persistently high nose-up attitude. This is likely to have contributed to increasing the rearward acceleration and unintended descent to a height below the helideck they had taken off from.

The commander who occupied the right-hand seat told the NSIA that he observed an oil rig on his right, which was moving forward from behind in relation to the direction in which the helicopter was moving. The oil rig in question was Maersk Invincible, the place of departure. The CVR recordings indicate that there was confusion at that point about which of the two pilots was at the controls. The first officer first expressed uncertainty as to whether the commander was operating the controls at TDP + 23 seconds. Initially, the commander answered this question in the negative. The commander did not confirm that he was operating the controls until 11 seconds later, i.e. TDP + 34 seconds.

CVFDR information has shown that CRM and communication between the pilots was not working optimally during this period, which was also confirmed by the pilots after the incident. The two-challenge rule and correct handover of the flight controls had no effect because both the first officer and the captain appear to have been significantly disoriented and stressed.

The NSIA believes that the disorientation occurred abruptly and unexpectedly, which in turn led to CRM and crew cooperation with the transfer of flight controls during the acute stress that arose not being as expected. The moment of surprise, and stress in itself can be a great threat to the communication skills, the cooperation between the pilots and how they solve their tasks. The same applies to the stress the crew experienced during the challenge of interpreting the instruments to understand the situation.

The threshold for taking over the flight controls when suffering from disorientation and being incapable of interpreting the information presented on the display in the cockpit is naturally very high. The fact that the commander became aware of and established visual contact with the oil rig on his right may have been essential for improving his situational awareness. He thereby became capable of taking over the controls and correcting the manoeuvring of the helicopter so that the parameters for a stable flight profile could be established.

Sensory illusions may have caused crew disorientation, with subsequent manual overcorrection of the flight controls. The NSIA believes that sensory illusions should be included as an important element in the helicopter operators' simulator training so that it can be more easily identified as a challenge and thus be included in the Threat and error management (TEM) prior to departure, see chapter 2.8.

Spatial disorientation caused by Degraded Visual Environment (DVE) is one of the most common causes of fatal helicopter accidents. The NSIA believes that helicopter operators should consider using USHST Recommended Practice: Spatial Disorientation Induced by a Degraded Visual Environment (H-SE 127A) as a supplement for training purposes.

2.7 Procedures and standard callouts

The helicopter operator has specified a number of standard callouts in its procedures; see Appendix B. The purpose is to ensure a common standard for communication between the pilots during all phases of the flight, and thus contribute to improving safety, among other things by making it easier to detect any incapacity to control the helicopter. Many of the standard phrases are used in connection with deviations from the helicopter's pre-defined and planned flight profile.

Operations Manual A, Deviation Calls, section 8.3.23.3 lists a number of standard calls for deviations in altitude, speed and sink rate. However, it does not include a standard callout for deviation in pitch attitude. As a consequence, there are no pre-defined limits for pitch attitude and no standard deviation call for the exceedance of such limits, which could give rise to an unusual attitude situation.

The NSIA considers that the absence of standard deviation calls for abnormal pitch variations can contribute to miscommunication and misunderstandings while seeking to re-establish a normal flight profile. The NSIA submits a safety recommendation to Bristow Norway related to this.

2.8 Threat and error management (TEM)

Section 1.18.4 refers to two similar aviation incidents that occurred in 2016 and 2019. Those two incidents have much in common with LN-ONT's departure from Maersk Invincible, even if the deviation from the planned flight profile was corrected at an earlier point in time. All three incidents occurred during departure from an offshore oil rig in night-time conditions, without an external visual horizon, and with the first officer in the left-hand seat as PF. In all three incidents, the helicopter deviated from a normal departure profile just after take-off, and the commander had to take control of the flight.

In the excerpts from the internal investigation reports that the helicopter operator carried out following the incidents in 2016 and 2019, great attention was drawn to the importance of the fact that the pilots, under demanding conditions, did not do a pre-takeoff check that included elements of TEM and that this should be part of the checklist. It would serve the purpose of ensuring that any threats to a safe flight were identified and dealt with through communication between the pilots before take-off. However, this is not included in the pre-takeoff checklist even though point 3. *Brief and VToss As Required* is present.

Operations Manual A 4.5.11 Crew Briefings, see Appendix B, describe that it is up to the pilot whether a full briefing should be given before departure or whether only the term «standard briefing» should be used. In this case, there was no briefing on special challenges that could arise during this departure in the dark, bad weather and without external references.

The NSIA believes that if TEM had been taken care of during this flight, the crew would probably have been better prepared, not so surprised and not as stressed during the departure.

The NSIA considers that the term "standard briefing" very likely does not capture and identify the threats to a safe departure under particularly demanding conditions.

In the NSIA's opinion, although TEM is taken into consideration in the helicopter operator's operational documents, it should to a greater extent be incorporated as a natural and visible part of day-to-day operations.

TEM should also be an important part of the CRM training in the simulator. In order to succeed in a real behavioural change where TEM is actively used, TEM should be a regular training element during semi-annual simulator training. Both instructors and flight examiners should expect the pilots to actively use TEM during training to detect threats to safe flight and that it is reflected in the daily operation. In other words, the threshold for using the term "standard" in the context of the Take off Brief should be high.

Threat and error management (TEM) is currently described in the Expanded Checklist in Operations Manual Part B. The NSIA believes that the possibility of omitting important elements related to departure from the helicopter deck under particularly demanding conditions is still present. The importance of regular TEM training and actively using TEM in daily operations to uncover any threats to safe flight must not be underestimated. The NSIA submits a safety recommendation to the Civil Aviation Authority of Norway (CAA-N) related to this.

3. Conclusion

3. Conclusion

3.1 Main conclusion

The incident occurred in challenging weather conditions during departure from the Maersk Invincible oil rig before the minimum speed for engaging the autopilot (V-min) was reached. The investigation has not found any technical faults or irregularities relating to the helicopter that may have impacted the sequence of events.

The NSIA finds that the first officer was probably exposed to spatial disorientation. This led to him overcorrecting the flight controls which in turn caused the helicopter to deviate from a normal departure flight profile. Whether it was done intentionally or not, failure to release the cyclic trim switch to set aircraft reference pitch attitude, the correct pitch-up attitude to climb and trim out the resistance in the cyclic probably contributed to aggravate the situation.

For a period, the commander was exposed to spatial disorientation. The crew were in a stressful situation and the commander himself has described that the CRM did not work as expected during this period. When the commander made visual contact with the oil installation on the right side of the helicopter, he regained his situational awareness and took over the flight controls.

If only one of the pilots perceives that he has lost situational awareness, good CRM would be to give the flight controls to the other pilot. In this incident, however, both pilots were for a period subject to disorientation simultaneously. When both pilots have the perception that they are unable to form an understanding of the situation, it is difficult to describe what would be effective CRM.

The NSIA finds that increased training regarding Threat and Error Management (TEM) could have contributed to increased awareness of any safety threats under particularly challenging departure conditions as in the present case. The importance of consciously using TEM actively in daily operations must not be underestimated.

The NSIA also believes that the autopilot in Sikorsky S-92A helicopters, which are used for passenger transport, should be upgraded with low-speed modes. This includes Rig Approach System where departure mode features could make a significant contribution to improved safety during take-off from a helideck in particularly difficult conditions and should disorientation occur.

The NSIA finds that when it comes to deviation calls, there is no call, which alerts the pilot flying the helicopter, about abnormally nose-up or abnormally nose-low position. An implementation of a deviation call for abnormal pitch attitude according to situation will most likely contribute to correct communication between the pilots and thus increased safety.

3.2 Investigation results

A. The aircraft was properly registered and had a valid certificate of airworthiness.

B. Available information does not indicate that any technical faults or deficiencies in the helicopter affected the course of events.

C. The helicopter was equipped with a voice recorder and flight data recorder (CVFDR), which made it possible to determine an exact course of events.

D. The departure direction of the helicopter was such that the oil installation with all its illuminated structures was located behind the helicopter.

E. The crew on board had valid certificates and rights to perform relevant assignments on board.

F. The helicopter's searchlight pointed straight ahead during takeoff, and not tilted down towards possible refereces.

G. The aviation incident occurred during the transition from visual flight to instrument flight during night conditions and without an external horizon.

H. Both the first officer, who was initially on the flight controls, and the commander experienced spatial disorientation.

I. The helicopter reached a backwards ground speed of 49 kts (90.748 Km/t) while losing altitude with a high nose position.

J. Data from CVFDR has shown that for a period there was a loss of situational awareness.

K. The company conducted an internal investigation and implemented several measures to increase safety after the aviation incident.

L. At the time of the incident, the helicopter operator did not have a fixed routine for using the cyclic force trim release button and has subsequently introduced approved procedures for best practice in its use.

M. When it comes to deviation calls, there is no call, which alerts the pilot flying the helicopter, about abnormally nose-up or abnormally nose-low position.

N. Threat and error management (TEM) is not currently specified on the operator's Offshore Pre-Takeoff Checklist. That means that there is a possibility of not identifying potential threats to safety and a plan for dealing with related challenges. This is particularly important in connection with helideck departures in particularly challenging conditions.

O. The minimum indicated airspeed of the helicopter type for engaging the autopilot is 50 kt.

P. The helicopter manufacturer has further developed upgrades for the helicopter type autopilot that enable lower speeds for engaging the autopilot, and which can help to stabilize the helicopter according to known flight parameters during take-off should disorientation occur.

4. Safety recommendations

4. Safety recommendations

The Norwegian Safety Investigation Authority submits the following safety recommendations:[13]

Safety recommendation Aviation No 2024/02T

The serious aviation incident on 24 February 2020 involving a Sikorsky S-92A, LN-ONT, occurred in the dark and in very challenging conditions where the crew had no external visual horizon or visual references. The pilots lost control of the helicopter during manual flying just after take-off from the Maersk Invincible oil rig as a result of disorientation and lack of situational awareness. Threat and Error Management (TEM) is currently described in the Expanded Checklist in the Operations Manual Part B. This investigation shows that the possibility of omitting important safety elements related to departure under particularly demanding conditions is still present. Active use of TEM in order to uncover threats to safe flight must be reflected in the daily operation.

The Norwegian Safety Investigation Authority (NSIA) recommends that The Norwegian Civil Aviation Authority (CAA-N) in its supervisory activities with offshore helicopter operators emphasize following up the operators' procedures and routines related to TEM, TEM training and how TEM is managed in daily operations.

Safety recommendation Aviation No 2024/03T

The serious aviation incident on 24 February 2020 involving a Sikorsky S-92A, LN-ONT, occurred in the dark and in very challenging conditions where the crew had no external horizon or visual references. The helicopter was flown manually, and, as a result of the pilot at the controls becoming disorientated, a situation arose with loss of control of the helicopter and a high pitch-up attitude. The Standard Deviation Calls do not include a deviation call for abnormal variations in pitch attitude. The NSIA considers that the absence of standard deviation calls for abnormal pitch variations can contribute to miscommunication and misunderstandings while seeking to re-establish a correct flight profile.

The Norwegian Safety Investigation Authority (NSIA) recommends Bristow Norway AS that the Standard Deviation Calls be extended to also include deviation calls for pitch variations that exceed predefined limit values.

Norwegian Safety Investigation Authority
Lillestrøm, 14 February 2024

[13] The Ministry of Transport forwards safety recommendations to the Civil Aviation Authority and/or other involved ministries for evaluation and monitoring; see Section 8 of the Norwegian Regulations on public investigations of accidents and incidents in civil aviation.

Abbreviations and references

Abbreviations

AFCS	Automatic Flight Control System
ALT P	Altitude Pre-Select
ARA	Airborne Radar Approach
CRM	Crew Resource Management
CVFDR	Combined Voice Flight Data Recorder
EASA	European Union Aviation Safety Agency
EFP1	Engine Failure Point 1
EFP2	Engine Failure Point 2
EGPWS	Enhanced Ground Proximity Warning System
EHEST	European Helicopter Safety Team
FAA	Federal Aviation Authority
FDM	Flight Data Monitoring
ICAO	International Civil Aviation Organisation
IFR	Instrument Flight Rules
MFD	Multi-Functional Display
NSIA	Norwegian Safety Investigation Authority
NTSB	National Transport Safety Board
OPC	Operator Proficiency Check
SAR	Search and Rescue
SAS	Stability Augmentation System
SOP	Standard Operating Procedures
TDP	Take-off Decision Point
TEM	Threat and Error Management
UPR	Upset Prevention and Recovery
USHST	United States Helicopter Safety Team

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Appendices

Appendix A Description of Sikorsky S-92A ground proximity warning system

General information

LN-ONT was equipped with an enhanced ground proximity warning system (EGPWS) that warns the pilots both visually and by voice messages if the helicopter gets close to the ground, sea or obstacles stored in the system's database. The S-92 Flight Manual and S-92 Pilot Training Manual describes six different EGPWS modes.

A new standard for Helicopter Terrain Awareness and Warning System (HTAWS) (ED-285/DO-376) was published in 2021 and will be useful for designers, manufacturers and users of Offshore HTAWS.

EGPWS modes

Mode 1 alerts the pilot of an excessive sink rate in relation to the helicopter's altitude above terrain or the sea. The EGPWS has a low altitude switch in the cockpit that can be activated if the intention is to operate the helicopter at altitudes below 500 ft. Activation of the switch will deactivate Mode 1. Mode 1 does not issue alerts during autorotation.

Mode 2 is a 'look-ahead' mode, alerting the pilot of an excessive rate of closure with the ground, because of a high sink rate or based on the projected flight path ahead. Mode 2 exists in two forms: modes 2A and 2B. Mode 2A is used during horizontal flights and is active when the landing gear is retracted and at radar altitudes exceeding 30 ft. Mode 2B is designed to warn of obstacles during approach and landing. In Mode 2B, the voice message '*Terrain, Terrain'* will be repeated twice in the course of seven seconds when one of the following three conditions are present: 1) The landing gear is extended, 2) There is a glideslope deviation during an IFR approach, and 3) Sinking within 60 seconds of departure. The system is designed to give 30 seconds warning before impact with the ground (corresponding to approximately 1 NM at an airspeed of 120 kts). At 20 seconds before potential impact, the visual warning changes from yellow to red and the voice warning is repeated continuously: '*Warning, Terrain – Warning, Terrain*' or *'Warning, obstacle – Warning, obstacle'*. Mode 2 is also deactivated when the low altitude switch is activated or the helicopter is in autorotation.

Mode 3 alerts the pilot of loss of altitude immediately after take-off. For Mode 3 to issue warnings to pilots after take-off, the landing gear must have been retracted or the indicated airspeed must be greater than 50 kts. The mode will be active until the helicopter has reached a sufficient altitude and other EGPWS modes will protect against a CFIT. However, so that the system does not issue warnings in connection with an aborted take-off, Mode 3 is deactivated at indicated airspeeds below 40 kts. The logic behind this is that, if the helicopter is sinking and has an indicated airspeed of less than 40 kts, the system interprets it to mean that the pilot is making an intended effort to land the helicopter and will not issue distracting warnings. When descent is detected after take-off, the pilot will hear the audio message *'Don't sink, don't sink'* in his headphones at the same time as the message is shown in clear text, in black letters against a yellow background, on the instrument panel display.

Mode 4 alerts the pilot when the helicopter is flown below a pre-selected altitude above the terrain. It has three sub-modes in which the audio messages depend on the helicopter's speed and on whether or not the landing gear is extended. These are modes 4A, 4B and 4C, the latter of which is designed for deviations during the take-off phase. If the radar altitude is below 150 ft, the landing gear retracted and the indicated airspeed exceeds 40 kts, the warning *'Too Low – Terrain'* will be activated.

Mode 5 is designed to warn of glideslope deviation during instrument flying, and **Mode 6** issues the voice warning *'Altitude, altitude'* when the helicopter is descending through the altitude set on the radar altimeter and voice warnings for 100 ft radar altitude, excessive banking and excessive nose-up attitude during autorotation.

Summary

In connection with the incident under consideration, EGPWS Mode 6 issued the voice alert *'Altitude, altitude – altitude, altitude'* to the pilots immediately after take-off. When the captain had taken over the controls and intentionally initiated forward acceleration, the helicopter continued to lose altitude while the airspeed increased. During this period of sinking, Mode 3 issued the voice warning *'Don't sink, don't sink'* to the pilots in accordance with what the system is designed to do.

It is worth knowing that EGPWS Mode 3 protection is designed so that warnings cease when the helicopter's indicated speed drops below 40 kts. The manufacturer considered the decision to use 40 kts as the lowest limit value for Mode 3 with the landing gear extended to be an acceptable compromise with a view to avoiding false and distracting warnings in connection with aborted take-offs. The manufacturer's decision was also influenced by the belief that any inadvertent descent after take-off would not occur concurrently with a significant reduction in speed. This leaves a gap in the protection afforded by the S-92A's EGPWS, however.

For example, if the helicopter takes off with the landing gear extended and an inadvertent descent occurs before it reaches an indicated airspeed of 50 kts, or if the speed drops to below 40 kts after reaching 50 kts, the EGPWS will not provide any protection against a CFIT regardless of the sink rate. This applies correspondingly in connection with an approach. If the speed drops below 40 kts with the landing gear extended, the EGPWS affords no protection against an inadvertent descent. In other words, the EGPWS does not have any defined limit value for the sink rate that can differentiate between a controlled and uncontrolled descent that can result in a CFIT.

Appendix B Excerpt from the helicopter operator's procedures (OMA/OMB)

OMA 4.5.1.3 Duties

PF shall:

- Guard the controls at all times during ground operations.
- In flight, and with FD coupling functions engaged, the PF will monitor the aircraft and be ready to take control when necessary. When flying manually, control shall be positive.
- Concentrate on flight path control and be in charge of aircraft control;
- At all times monitor any FD coupling functions.
- Keep the aircraft within prescribed parameters;
- Aim for precise, smooth and safe operation;
- Respond to all Callouts according to Crew Communication procedures;
- Initiate checklists

PM shall:

- Assist the PF with controlling, achieving and maintaining the required power setting, as briefed;
- Monitor flight path, navigation, power settings, procedures, aircraft systems and FD coupling functions;
- Read and perform Checklist actions;
- Support PF in order to reduce his workload;
- Do all the administrative work in the cockpit, including all radio communication;
- Take over control in case of incapacitation;
- Perform Callouts in accordance with Crew Communication procedures;
- Normally perform the passenger briefing.

Note: Until at safe altitude (500 ft AGL) and speed (Vy), PM shall concentrate mainly on:

- Power setting (t/o power);
- Rate of climb;
- Heading (flight path) and;
- Supporting the PF with deviation calls, corrective action and information about flight path to be followed (heading, altitude, etc.).

The PM is responsible for advising the PF immediately, should he have any reason to believe that the helicopter is being handled improperly by deviation from standard operational procedures, or safe operation is jeopardized in any way.

OMA 4.5.11 Crew Briefings

Take Off and Landing Briefings must be memorized by all Flight Crew Members. It is the decision of the briefing pilot, whether he wants to give a full standard briefing, or just use the term “Standard Briefing”.

The Briefing pilot should focus on giving a concise briefing with focus on anything that may be a deviation from the norm/ expected. The Briefing pilot should keep in mind that a very long and detailed briefing may clutter the most important elements of the phase to be briefed.

In order to avoid confusion on the flight deck, the PF shall always make a statement of intent in case of a single engine failure or any other major malfunction. The following statements of intent shall be used:

OMA 4.5.11.1 Statement of Intent

Before "TDP/Committed" .... "Landing"

After "TDP/Committed" .... "Continuing" or "Ditching"

Before "LDP/Committed" .... "Going Around" or "Landing"

After "LDP/Committed" ...."Landing"

OMA 4.5.11.2 Takeoff Briefing

The complete take-off briefing must contain the following elements before every take-off:

- Take-off profile
- Definition of TDP
- Use of automation
- Departure procedures and any non-standard elements,
- “Standard Briefing” if full briefing is not given (Note 1 & 2)
- A briefing of elements in the take-off from Helideck which require a special attention or crew coordination effort in order to reduce risk exposure. (Obstructions, wind condition, or when special attention to maneuvring or handling of the helicopter is required.)

Note 1: All onshore LVTO’s shall contain the following as a part of the take-off briefing:

> *At TDP I will call delay or committed depending on visual conditions and remaining runway length available.*

Note 2: When the term “Standard Brief” is used in relation to actions at TDP the following implies:

> *In case of a major malfunction before I have called “committed” we will land back. In case of a major malfunction after I have called “committed” we will continue. You will advise me of NR, Rad Alt and IAS. Only immediate actions may be performed before reaching safe altitude and speed (500’ and VY). Standard Calls will be used.*

Note 3: If a take-off profile is used which could result in a ditching, crew duties and procedures to be followed shall be briefed in detail.

OMA 4.5.11.3 Power Control

The recommended procedure is to let the PM assist in controlling the take-off power. The PM will put his hand on the collective lever and assist the PF in achieving and maintaining the correct power setting. This must be covered as part of the take-off briefing. The power setting to be used must be clearly stated, e.g. "*You will assist me in achieving and maintaining between 96–98% torque*".

OMA 8.3.23.3 Deviation Calls

The following deviations from the planned flight path require a Deviation Call from the PM:

More than	**Call**
10 kts from intended IAS (if required)	"IAS 10 kts fast/slow"
+50 ft / -20 ft from altitude (height) on MDA(H)	"Altitude 50 ft high/low"
100 ft above/ below assigned/intended altitude/ height in cruise	"Altitude 100 ft high/low"
5° from assigned/intended heading/track	"5° left of heading"
Bank angle more than 30° AEO or 20°OEI	"Check bank angle"
1000 ft/min ROD or 600 ft/min ROD below 500 ft	"Sink rate high"
1 dot on LOC and/or G/S	"1 dot high/low on G/S" (own position relative to beam)

Note: The calls "fast" and "slow" are used in connection with speed, and that the calls "high" and "low" are used in connection with altitude / height, in order to avoid confusion.

The PF shall respond verbally to the deviation calls, e.g. "*Roger Correcting*", and take corrective action. If the PF does not respond, or does respond but does not correct the deviation, the PM shall repeat the deviation call followed by a recommended corrective action: example "*IAS still 15 kt fast*", "*reduce torque 3%*". If the PF still does not respond correctly, the PM shall, if circumstances permit, challenge the PF again and will include the words: "*If you do not make a correction, I will assume control*" (ref. chapter 4.3 Flight Crew Incapacitation).

Under no circumstances should the PM allow such time to pass between his initial deviation call and is final assumption, that the helicopter and occupants are unreasonably endangered.

Should the disorientation be recognized initially by the PF he shall state "*Disoriented, you have control*".

Caution: The importance of transferring controls in a positive manner (You have the controls/ I have the controls) at an early stage in case of spatial disorientation can never be overestimated. PF must do this in order to increase the chances of a successful handover to the PM, who can, if necessary, regain control over the aircraft.

OMA 8.3.10.3 Sterile Cockpit

During critical phases of flight, no Crew Member should perform activities or communication that is not required for the safe operation of the helicopter. Required crew communication shall be as clear and distinct as possible. Correct Crew Communication procedures will help discover Flight Crew Member Incapacitation.

Note: Critical phases in this context are ground operation, (taxi or on deck), take-off, departure, approach, landing or any abnormal/emergency situation. Take-off and departure phase is considered to be complete when leveling off at cruising altitude/ level and checklists are completed.

OMB 2.2.6 Helideck Take-Off

PF should be the pilot with the best references to the helideck and/or obstructions on the offshore installations. Transfer of controls shall normally be done after aircraft is leveled off at cruise unless an operational reason makes it necessary to change controls earlier. This should be briefed before departure. The FD that corresponds to the pilot that will be PF on the next sector may be engaged on deck.

Perform the applicable checks according to the checklist. Performance charts may be checked in advance.

OFFSHORE PRE-TAKEOFF

1.	▶GROSS MASS	ADJUST
2.	▶CABIN SIGNS/PAX	ON/BRIEF
3.	▶BRIEF AND VTOSS	A/R
4.	COMPASS/NAVAIDS	CHECK/SET
5.	ECS	ON
6.	ANTI ICE	A/R
7.	TRANSPONDER/SMS	SET/SEND
8.	▶DOOR AND RAMP	SECURED
9.	CHOCKS	REMOVED
10.	▶ATS/HELIGUARD	CLEARENCE
11.	▶ANTI COLL/LANDING LIGHTS	ON
12.	▶FLOTATION GEAR	ARM
13.	▶PRE LIFT OFF CHECK	PERFORM

CHECKLIST COMPLETED

▶: Shuttle items

BLUE: Offshore

Figure B1: The Offshore Pre-Takeoff Checklist applicable at the time of the incident. In a revised version dated 12 April 2019, minor changes were made concerning the order and merging of some checkpoints. 'Threat and Error Management' was not included in the checklist. Source: Bristow

Lift the helicopter into a 5' hover over the reference circle, placing the pilot seat over the forward area of the circle or approximately 15' from the deck edge.

PM performs hover checks by memory and finishes with "Hover check complete", indicating that everything is OK for T/O.

Note

See Operations Manual Part A: "*Duties*" "***note***" and "*Power Control*".

> *1. Back up on power control from PM is recommended during the helideck Take-Off to ensure that correct take-off torque is achieved early. It is important to ensure that the vertical speed at TDP is at the maximum by increasing collective pitch rapidly to takeoff torque according to point 4 below. This again to ensure deck clearance if an engine should fail after TDP.*

When operating according to this procedure, performance is available to permit continued OEI flight, except when an engine failure occurs early during takeoff maneuver, in which case a forced landing might be required.

1. Determine maximum take-off mass from RFM

2. Determine VTOSS and set VTOSS on the airspeed gage.

3. Calculate take off torque by summing the Delta torque value and the HIGE torque value.

4. Establish a vertical climb by rapidly increasing collective pitch to achieve take off torque determined. Do not exceed maximum take-off power.

5. When climbing through the TDP (30 feet AGL), rotate the aircraft 10 to 20 degrees nose down.

Sikorsky states:

when we say 10 to 20° nose down we mean from the vertical climb attitude (which usually matches the hover attitude). If you are climbing/hovering at 5° nose up, then you will pitch over to 5 - 15° nose down on the attitude indicator". Recommended procedure is 10-15 during day and good visibility and only 5° nose down at night or during times of low visibility.

6. When approaching VTOSS, rotate to a climb attitude of approximately 5 degrees nose up.

7. After clearing obstacles, continue acceleration and climb as required.

Standard Calls and Deviation Calls according to Company OMA & OMB, ref;

OMB 2.2.6.1 Standard Calls

Standard calls to be used are:		
PF:	"Lifting"	PM: Monitor
PF:	"Go"	PM: Monitor
PM:	"TDP"	PF: "COMITTED"
PM:	"VTOSS, POSITIVE CLIMB, TORQUE XX"	"PF:"CHECKED"
PM:	"VY, POSITIVE CLIMB, TORQUE XX "	PF:"CHECKED"

In case of a major malfunction PF will state his intent "LANDING" or "CONTINUING". In case of a ditching, the Commander will normally take control and call "DITCHING".