

CIAIAC

COMISIÓN DE
INVESTIGACIÓN
DE **A**CCIDENTES
E **I**NCIDENTES DE
AVIACIÓN **C**IVIL

Report A-002/2010

Accident involving an
AgustaWestland AW139 helicoter,
registration EC-KYR, operated
by INAER HELICÓPTEROS
OFF-SHORE off the coast
of Almeria, on 21 January
2010 at 20:16 local time



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SUBSECRETARÍA

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DE ACCIDENTES E INCIDENTES
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Foreword

This report is a technical document that reflects the point of view of the Civil Aviation Accident and Incident Investigation Commission (CIAIAC) regarding the circumstances of the accident object of the investigation, and its probable causes and consequences.

In accordance with the provisions in Article 5.4.1 of Annex 13 of the International Civil Aviation Convention; and with articles 5.5 of Regulation (UE) n° 996/2010, of the European Parliament and the Council, of 20 October 2010; Article 15 of Law 21/2003 on Air Safety and articles 1., 4. and 21.2 of Regulation 389/1998, this investigation is exclusively of a technical nature, and its objective is the prevention of future civil aviation accidents and incidents by issuing, if necessary, safety recommendations to prevent from their reoccurrence. The investigation is not pointed to establish blame or liability whatsoever, and it's not prejudging the possible decision taken by the judicial authorities. Therefore, and according to above norms and regulations, the investigation was carried out using procedures not necessarily subject to the guarantees and rights usually used for the evidences in a judicial process.

Consequently, any use of this report for purposes other than that of preventing future accidents may lead to erroneous conclusions or interpretations.

This report was originally issued in Spanish. This English translation is provided for information purposes only.

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Abbreviations

00°	Degree(s)
AAIB	Air Accident Investigation Branch (aviation accident investigative agency in the United Kingdom)
AEMET	Spain's National Weather Service
AESA	Spain's Aviation Safety Agency
ALAR	Approach and landing accident reduction
AP ATT	Autopilot long-term stabilization
ATC	Air traffic control
AW	AgustaWestland
BOM	Basic Operations Manual
CAA	The United Kingdom's Civil Aviation Authority
CFIT	Controlled Flight Into Terrain
CIAIAC	Spain's Civil Aviation Accident and Incident Investigation Commission
COSPAS-SARSAT	Space System for the Search of vessels in distress and Search And Rescue Satellite-Aided Tracking
CRM	Crew resource management
CVR	Cockpit voice recorder
DGAC	Spain's Civil Aviation Directorate General
DH	Decision height
EASA	European Aviation Safety Agency
ELT	Emergency locator transmitter
FAF	Final approach fix
FD	Flight director
FDR	Flight data recorder
ft	Feet
FTR	Force trim release
GS	Ground speed
h	Hour(s)
hPa	Hectopascal
IAF	Initial approach fix
ICAO	International Civil Aviation Organization
IF	Intermediate fix
IFR	Instrumental flight rules
INTA	Spain's National Institute for Aerospace Technology
IR	Instrument rating
JAR-FCL	Joint aviation authority - flight crew license
km	Kilometer(s)
kt	Knot
LEAM	ICAO callsign for the Almeria Airport
LOSA	Line operations safety audit
m	Meter(s)
MAP	Missed approach point
MCC	Multicrew cooperation
MCL	Master caution light
MEL	Master equipment list
METAR	Aerodrome Meteorological Report
MFD	Multifunction flight display
MMEL	Master minimum equipment list
MOT	Mark on target
N	North
NM	Nautical mile
PF	Pilot flying
PFD	Primary flight display
PNF	Pilot not flying
P/N	Part number

Abbreviations

QNH	Altimeter setting required to obtain the airport's altitude above sea level
RHT	Radioheight
ROV	Remotely operated vehicle
SAR	Search and rescue
SAR SOM	Search and Rescue Special Operations Manual
SASEMAR	Sociedad de Salvamento y Seguridad Marítima
SMS	Safety management system
S/N	Serial number
SRM	Safety risk management
TD	Transition down
TDH	Transition down to hover
TQ	Torque
TU	Transition up
UTC	Universal time coordinated
VFR	Visual flight rules
VOR/DME AMR	Almeria VOR/DME
W	West
WTR	Winchman trim

Synopsis

Owner:	SASEMAR
Operator:	INAER HELICÓPTEROS OFF-SHORE, S.A.
Aircraft:	EC-KYR AgustaWestlan AW139
Date and time of accident:	Thursday, 21 January 2010; 20:16:02 local time
Site of accident:	36° 46.6145' N 002° 21.1665' W (in 91 m deep water 4.5 NM south of the Almeria Airport)
Persons onboard:	3, dead (pilot, copilot and rescue swimmer) 1, seriously injured (winch operator)
Type of flight:	Aerial work. Search and rescue. Training.
Date of approval:	18 September 2012

Summary of accident

On Thursday, 21 January 2010 at 20:16:02 h, an AgustaWestland AW139 helicopter, registration EC-KYR, crashed in a controlled flight into the water, inadvertently by the crew, 4.5 nautical miles (NM) south of the Almeria coast.

The aircraft had started operations at 18:00 h from the Almeria Airport, where it was based. It had been on a scheduled nighttime search and rescue (SAR) training flight for over two hours. At the completion of the training at 20:13:52 h, the aircraft started the return trip to the airport. Two minutes and ten seconds later, at 20:16:02 h, the helicopter impacted the water at a ground speed (GS) of 110 kt on a course of 081° with a 3.5° positive pitch angle and at a 1° right bank angle. The helicopter was destroyed by the impact and sank to the bottom in 91 m of water. The entire flight took place under nighttime conditions with no adverse weather.

Of the four persons onboard (pilot, copilot, rescue swimmer and winch operator), only the winch operator survived the accident.

Investigation determined that the accident is consistent with a controlled flight into water caused by the pilot's misperception of the aircraft's altitude resulting from a visual illusion generated by using external references, from a faulty interpretation of the instrument readings or from a combination of both, and to the copilot's failure to monitor the instruments.

¹ All times in this report are local, as obtained from the helicopter's flight data recorder. There is a 12-second delay between the reference times recorded at air traffic control stations and those noted on the FDR.

The following factors contributed to the accident:

1. Possible crew fatigue resulting from:
 - The demands of the SAR operation.
 - The excessive workload placed on the captain by assuming his own tasks and responsibilities and many of the copilot's.
 - The excessive cognitive effort made by the copilot due to a lack of SAR experience and to the effort required to understand and communicate in a foreign language.
2. Inadequate crew training in SAR operations and CRM techniques that:
 - Hampered the captain's handling of the unresolved conflict between giving the copilot more autonomy while fully confiding in his flying skills.
 - Prevented the copilot from being sufficiently assertive to communicate his difficulty in staying abreast of the flight due to the captain's unreported actions and his desire to complete the flight successfully with a captain who was very much his senior.
 - Impeded the captain and copilot from identifying and managing their fatigue.
 - Impeded the crew's handling of the transition between a highly demanding activity (SAR exercises) and a routine activity (return flight).
 - Resulted in the crew's constant exposure and habituation to the LANDING GEAR and ONE FIFTY FEET audio warnings, which made these warnings ineffective in preventing the impact.
3. The definition and inappropriate use of SAR checklists not adapted to the helicopter model and to SAR operations, and which included disengaging the Flight Director.
4. The lack of regulations specific to SAR operations in Spain and the low requirements placed on the operator by the provider of the SAR service.

This report contains 17 safety recommendations for State Aviation Safety Agency (AESA), as one of the bodies designated by Spain as its civil aviation authority, for the Spanish Maritime Safety Agency (SASEMAR), the responsible of the SAR service, for INAER HELICÓPTEROS OFF-SHORE, as the SAR operator, and for the European Aviation Safety Agency (EASA), as the certifying authority for the emergency locator transmitter.

1. FACTUAL INFORMATION

1.1. History of the flight

A nighttime search and rescue (SAR) flight was scheduled for helicopter EC-KYR for Thursday, 21 January 2010. The helicopter's flight crew consisted of a captain and copilot, and the non-flight crew included a winch operator and a rescue swimmer. The flight had been cancelled twice due to the copilot's stomach problems and to a technical problem with the helicopter which was, at the time, already fixed.

It was the aircraft's first flight of the day and the engines were started at 18:00 h. The sun set 33 minutes later, at 18:33 h. According to the winch operator, who survived the accident, it was a dark night. Weather conditions on takeoff and during the rest of the flight were good. There were no visibility problems and the wind was calm.

The day of the accident had been the captain's 14th duty day, only interrupted by one rest day on 11 January. Prior to that, he had had seven days of rest. Over the last ten days of continuous duty, he had been on a single SAR training flight, on January 13, lasting 2 hours and 40 minutes, and which he flew with the same copilot as on the accident flight.

The copilot had been on duty at the base since 8 January, meaning he had been on duty for 14 days straight on the day of the accident. This has been preceded by seven days of rest. In that time he had been on one SAR training flight on 13 January with the same crew as on the accident flight, and on two nighttime flights on 16 January.

The crew had arrived on the base at 12:00 h and had to stay there until 00:00 h, at which time it was to have been relieved by the night shift crew, meaning that by the time the flight commenced, they had been for six hours performing general activities. When pilots arrive at the base, they conduct a pre-flight check of the helicopter, review any reports affecting the helicopter, write mission reports, update manuals, gather weather information and review aviation notices that could affect them. Any time left over they devote to activities of their choosing (rest, exercise, reading, etc.). In addition to these duties, the captain was also the base commander, meaning that, in addition to having to be ready for any emergency, he was in charge of running the base.

On that day helicopter EC-KYR had six deferred items², which included an inoperative acoustic warning associated with the decision height (DH)³ and a flickering copilot display.

The training planned for that day included the following exercises:

² Described in Section 1.6.

³ This warning, however, worked during the accident flight.

1. The first exercise was an approach to hover (referred to by the crew as a “sea approach”).
2. The second exercise was to pick up survivors from a vessel, the Salvamar Denévola. This consisted of conducting an approach to hover⁴ above the moving Salvamar, lowering the rescue swimmer and the dummy⁵ to the Salvamar and hoisting them up again.
3. The third exercise involved picking up survivors from the water, with the Salvamar Denévola acting as the support vessel. The exercise included conducting an approach to hover over a stationary Salvamar and lowering the rescue swimmer into the water to simulate someone lost at sea. Once the swimmer was in the water, the helicopter would fly about 5 NM away to lose all references before returning to engage in the search and rescue of the swimmer.

The copilot made the first contact with the Almeria tower at 18:06:00 h to request takeoff clearance and to inform of the activities they would be conducting to the south of the airfield for about the next two and a half hours. At 18:10:02 h, the helicopter took off normally and proceeded to a point some 26 NM southeast of the airport, off Cabo de Gata, to conduct the first exercise.

The cockpit voice recorder (CVR) started to function at 18:14:06 h, with the helicopter flying at an altitude of about 1,000 ft. At 18:20 h, the copilot turned off one of his two flight displays, which was flickering, and selected the other display to show the most relevant information from both screens⁶. Two minutes later, while still en route to Cabo de Gata, the captain reminded the crew of the exercises to be conducted. The pilot flying was the copilot.

First exercise (figure 1)

The captain took over as pilot flying when they were 10 NM away from the vessel chosen by the captain for the first exercise. He conducted a manual⁷ approach to an altitude of 200 ft and then returned control to the copilot just as the CHECK HEIGHT⁸ warning, associated with the captain’s decision height (200 ft), sounded despite being listed as inoperative in the deferred item list. The copilot finished the approach to the ship and hovered, both in manual. The ship’s heading with respect to the wind was not

⁴ Described in Section 1.17.

⁵ The dummy is used in training exercises to simulate the victim to be rescued.

⁶ Specifically, he turned on the right display (MFD) and set the left (PFD) on composite mode, described in Section 1.6. In composite mode, the display selects certain information from each of the two screens and shows it on a single screen, keeping the display size the same. This practice had been commonplace in previous nighttime flights, as indicated by the FDR.

⁷ The term “manual” as used by the crew refers to the non-use of any Flight Director mode. The autopilot long-term stabilization system (AP ATT), described in Section 1.6, was engaged throughout the flight.

⁸ The CHECK HEIGHT aural warning, described in Section 1.6, is activated when the helicopter descends to the set decision height.

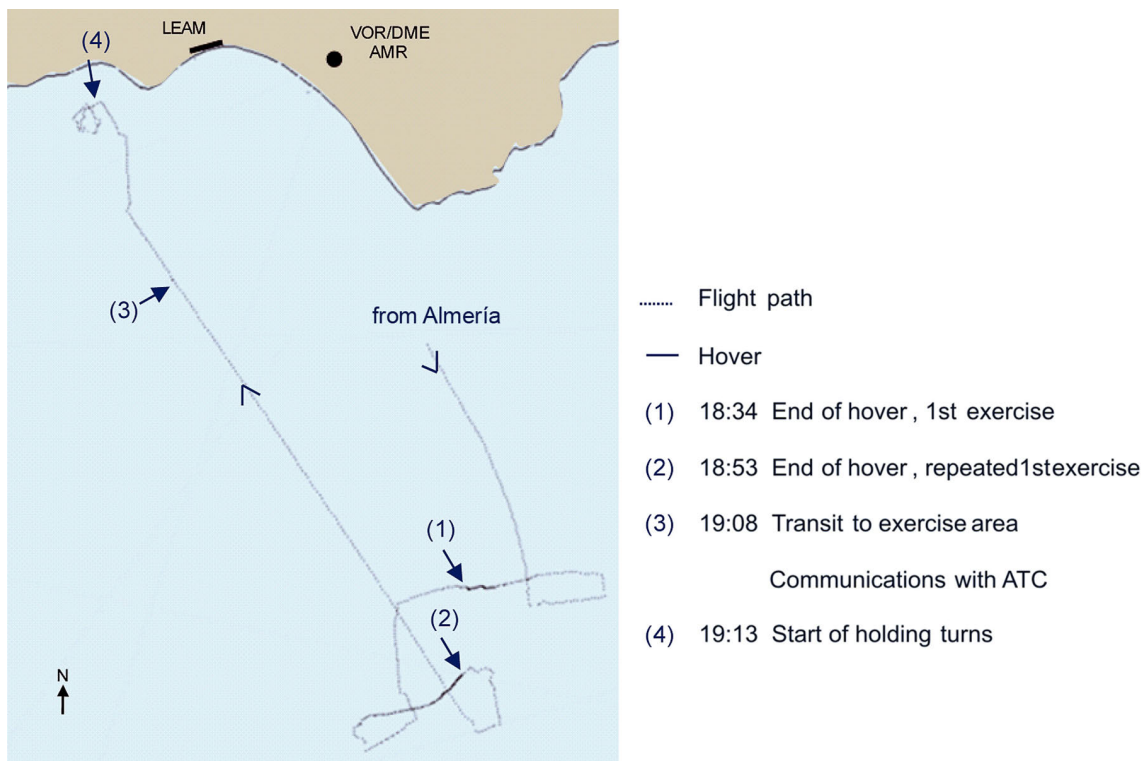


Figure 1. Radar flight path for exercise 1 and en route to the area for exercises 2 and 3

favorable, so they decided to terminate the hovering maneuver at 18:34 h and select another vessel to repeat the maneuver. The copilot climbed in manual to 500 ft and by 18:36:54 h had picked another vessel close to the first.

Repeat of first exercise (figure 1)

The first exercise was repeated some 30 NM away from the Almería Airport, also off Cabo de Gata. The pilot flying was the copilot. The entire maneuver was carried out in manual and the exercise was completed at 18:53:46 h, at which time they departed in manual again to 500 ft from a hovering attitude. The LANDING GEAR⁹ and ONE FIFTY FEET¹⁰ aural warnings sounded eight times each during the exercise.

Transit to the exercise area with the Salvamar (figure 1)

Three minutes later, at 18:56:49 h, the helicopter set off on a heading of 331° toward the exercise area with the Salvamar Denévola, with which they were scheduled to rendezvous at 19:15 h to carry out the second and third exercises. The altitude for the

⁹ The LANDING GEAR aural warning sounds when the aircraft descends below 150 ft and is not configured for landing. Described in Section 1.6.

¹⁰ The ONE FIFTY FEET aural warning sounds when below 150 ft. Described in Section 1.6.

transit was 500 ft. At 19:08:22 h, the captain informed Almeria tower that they were 9 NM south of the airport and would remain in the area at an altitude of 500 ft or less. By 19:13 h the helicopter was in the exercise area agreed to with the Salvamar and made four 360° holding turns.

Second exercise (figure 2)

At 19:19:27 h they began operations with the Salvamar, which reported a wind of 5 kt from 090°. The approach to the ship was made by the copilot in manual, during which time the LANDING GEAR and ONE FIFTY FEET aural warnings sounded. A minute later the copilot transferred control to the pilot for the winch operations. At 19:28:49 h the captain, now the pilot flying, started to hover. The exercise ended at 19:42:59 h as the helicopter departed from the hover. Both the hover and the climb were done in automatic (HOVER and RHT¹¹ for the hover and Transition Up¹² for the climb).

After the departure from the hover, the captain started a turn to the right and flew a pattern toward the Salvamar again for the final exercise.

Third exercise (figure 2)

During the circuit to align with the Salvamar for the last exercise, the captain once again briefed the planned exercise and requested that the Salvamar turn off its lights so as to

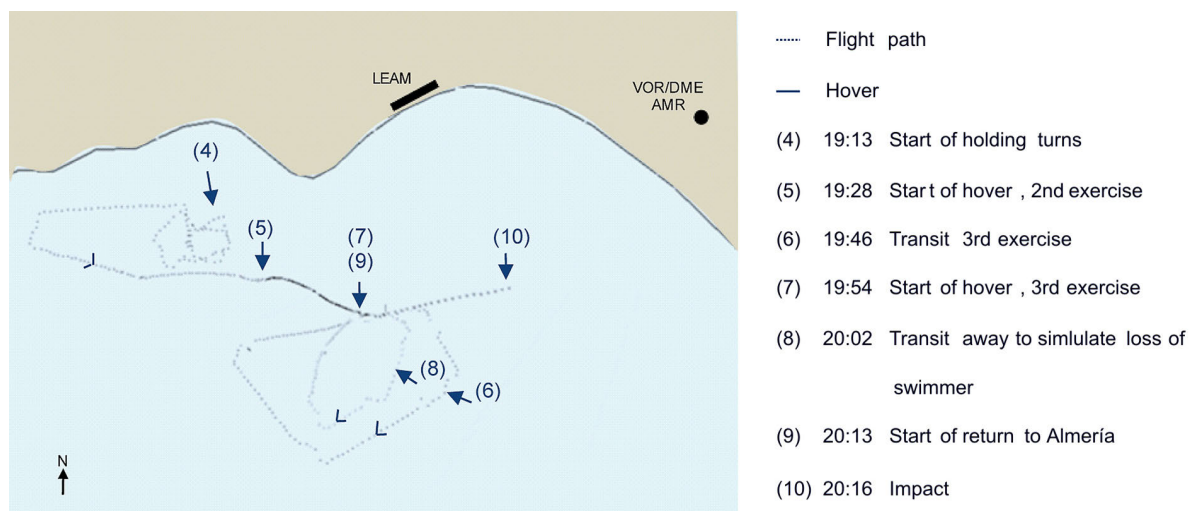


Figure 2. Radar flight paths for exercises 2 and 3 and return flight to Almería

¹¹ The HOVER and RHT modes are two flight director (FD) modes that automatically keep the helicopter at the position and altitude set by the crew. Described in Section 1.6.

¹² The SAR modes are functions designed and certified specifically for SAR activities. The SAR TU (transition up) mode takes the helicopter from a low speed and altitude to 200 ft and 80 kt.

establish realistic SAR conditions. The captain was the pilot flying. He made the approach to the ship in manual. The LANDING GEAR and ONE FIFTY FEET warnings sounded. At 19:54 h he started to hover using the HOVER and RHT modes. They lowered the rescue swimmer into the water and six minutes later, at 20:00:25 h, with the swimmer in the water and from a hover, the captain climbed in Transition Up mode, informing the swimmer that they were moving away in order to commence the search. They flew 2 NM away following an elliptical pattern and on the approach back, the LANDING GEAR and ONE FIFTY FEET warnings sounded again. By 20:06:32 h they had located the swimmer and were preparing to hoist him onboard.

By 20:13:27 h the swimmer and all of the material used in the exercise was onboard and the winch operator reported that he was closing the door. At 20:13:38 h, the captain stated that he was disengaging the HOVER and RHT modes¹³. The flight director was disengaged and placed in standby at 20:13:39 h and at 20:13:40 h, just as the captain reported he was disengaging HOVER and RHT, the winch operator reported "door closed and cabin clear", signaling the end of the last exercise. The helicopter was 5 NM southwest of the Almeria Airport at an altitude of 100 ft on a course of 082°.

The exercises lasted 1 hour and 25 minutes, not including flight operations (14 minutes for the first exercise, which was interrupted due to the wind, 19 minutes to repeat the first exercise, 23 minutes for the second and 29 minutes for the third).

Return flight to Almeria (figures 2 and 3)

At 20:13:46 h, the captain informed that he was starting the climb. The climb and the remainder of the flight until the impact took place in manual (that is, without engaging any mode in the FD, which was in standby). The captain continued as the pilot flying.

Two minutes and 10 seconds elapsed between the start of the climb (20:13:52 h) and the impact (20:16:02 h). The helicopter maintained the same course as during the final exercise (082°), increased its GS from 0 to 110 kt and performed a climb and a descent with a very smooth transition.

The climb was initiated with an input to the collective FTR¹⁴ to increase torque to 83% and with an input to the cyclic FTR. The pitch angle decreased from +5° to -2.5°. The maximum climb rate attained was 1,700 ft/minute, and the helicopter gained altitude and speed while maintaining the same course.

¹³ Specifically, he pressed the Standby button on the FD, which disengages the FD from the Autopilot.

¹⁴ The positions of the collective and cyclic can be changed in one of two ways: by using the FTR (Force Trim Release) and by transparency. The FTR acts by shifting neutral point to the desired location while the trigger or button is depressed. It is a deliberate action. The transparency mode does not involve setting a new control position. It is only a temporary repositioning, after which the previous neutral point is reestablished.

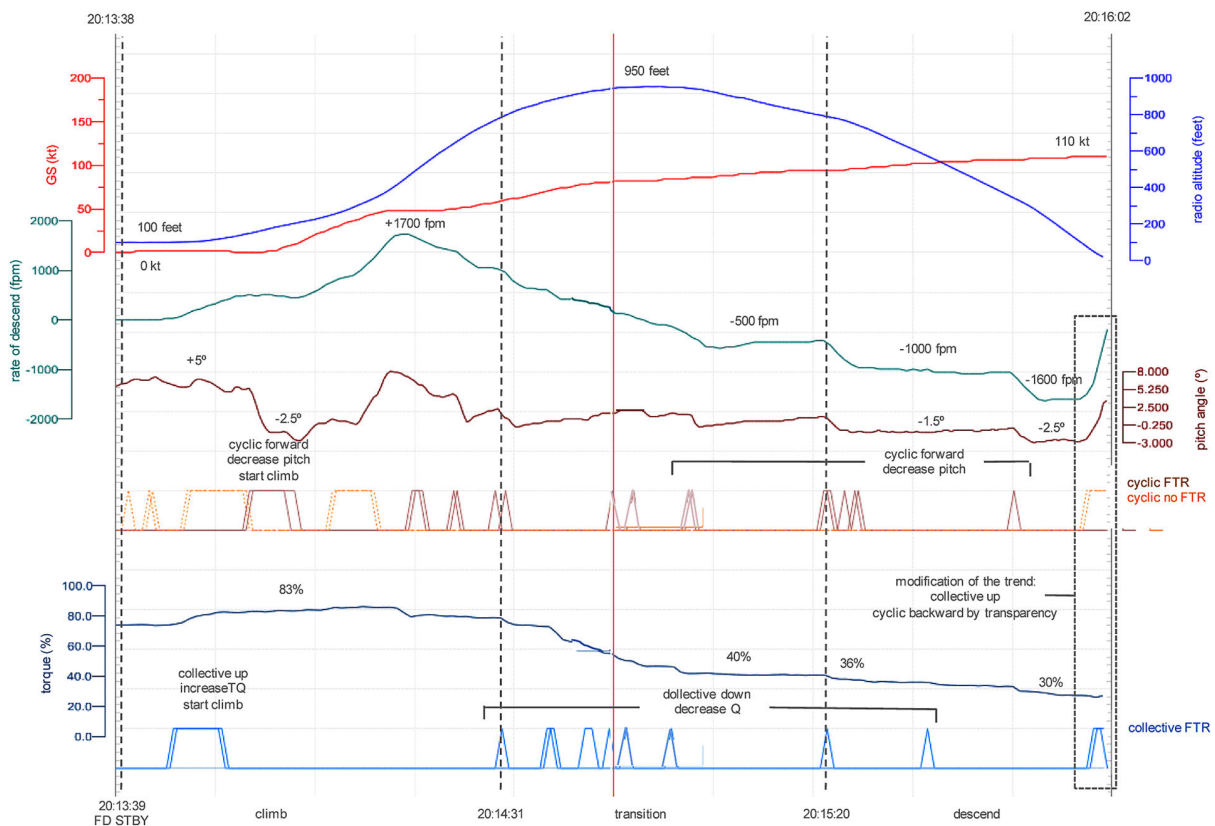


Figure 3. Return flight to Almeria. Flight profile and inputs to flight controls

At 750 ft, the captain started a series of six inputs to the collective FTR (decreasing torque to 40%) and to the cyclic FTR. These inputs were used to stop the climb and transition very gradually into the descent phase. The highest point reached in the trajectory was 950 ft at 20:14:59 h, with a GS of 90 kt. From that point until 780 ft, the helicopter descended at a rate of 500 ft/minute and increased speed.

At 20:15:20 h, with the helicopter at 780 ft and descending, a new input to the cyclic and collective FTRs decreased torque to 36% and lowered the pitch angle to -1.5° . This resulted in an increase in the descent rate to 1,000 feet/minute and increased the ground speed. At 20:15:36 h and 570 ft, the captain once again used the collective FTR to lower torque.

At 20:15:48 h, with the helicopter at 320 ft, a new input was provided to the cyclic FTR. The pitch angle reached -2.5° and torque dropped to 30%. As a consequence, the helicopter's speed and descent rate continued to increase, the latter to 1,600 ft/minute.

At 20:15:56 h, the helicopter was at 150 ft. The flight data recorder (FDR) revealed that the visual warning (MCL) associated with the landing gear position was energized, followed by the LANDING GEAR and ONE FIFTY FEET aural warnings, in that order. These two aural warnings sounded for six seconds, finishing half a second before impact. While the warnings were sounding, the crew was talking to ATC about refueling upon their return. No comments were made regarding the gear and 150 ft warnings.

At 20:15:58 h, with the aircraft at 100 ft, the captain deactivated the visual warning and provided the final inputs to the cyclic and collective controls. The cyclic control was pulled back slightly without using the FTR, and the collective was pulled up slightly using the FTR. These inputs, which were maintained until the moment of impact, reduced the vertical speed and increased the pitch angle.

At 20:16:02 h, the helicopter impacted the surface of the ocean. The last values recorded indicated a course of 081°, a ground speed of 110 kt, a 250 ft/minute descent rate, a +3.5 pitch angle and a 1° right bank angle.

At the time of the accident, the decision heights selected were 40 ft for the captain and 70 ft for the copilot.

1.2. Injuries to persons

The crew consisted of four individuals, of whom only the winch operator survived the accident. The pilot, copilot and swimmer were killed on impact.

Injuries	Crew	Passengers	Total in the aircraft	Others
Fatal	3		3	
Serious	1		1	
Minor				Not applicable
None				Not applicable
TOTAL	4		4	

Table 1. Injuries to persons

1.3. Damage to aircraft

The helicopter was destroyed by the impact with the ocean surface. After hitting the water, it sank and settled on the ocean floor at a depth of 91 m.

It was found upside down and slightly tilting to the right¹⁵. It was resting on the main rotor, on the area where the tail portion had fractured off and on one of the tail rotor blades. The nose and main fuselage (including the cockpit and passenger cabin) had detached and formed a tangled heap alongside the helicopter. The engines and rotors remained in their position and had not detached. The left engine cowling was open. The tail cone was still in its position and was bent in place at a 120° angle to the left. The main rotor was still attached to the fuselage though the blades were sheared and broken. The tail rotor blades were practically intact. The left horizontal stabilizer was broken, the landing gear was retracted, the emergency beacon had been ejected and the flotation system had not activated.

¹⁵ References to the structural components are described as seen from the rear with the helicopter in a normal position.



Figure 4. Condition of helicopter after impact. Images taken prior to recovery

1.4. Other damage

None.

1.5. Personnel information

1.5.1. Captain

Captain's experience

The 38 year old captain was born in Almeria. He had a JAR-FCL commercial pilot license with AW139, SA365/365N and instrument flight ratings and a valid medical certificate at the time of the accident. He joined INAER HELICÓPTEROS OFF-SHORE on 7 July 2007 with 3,600 flight hours. Prior to that he had been in the army where he had been a helicopter pilot. In his two and half years in the company, he had only been assigned to SAR activities and had been stationed at the base in Almeria since 31 May 2009.

He had a total of 4,000 flight hours, including:

- 2,163 h on the Sikorsky S-76C (950 hours as an instructor). Twin turboshaft engine.
- 1,015 h on the EC-120B (150 hours as an instructor). Single turboshaft engine.
- 499 h on the H-300C (200 hours as an instructor). Single piston engine.
- 335 h on the AW139, 5 hours under instruction. Twin turboshaft engine.
- 9 h on the SA365/365N. Twin turboshaft engine.

Of his 4,000 flight hours, most had been in daylight visual conditions. He had 155 h in nighttime visual conditions and 1,162 in IFR. He had 91 flight hours in nighttime SAR operations.

He had flown 117 h in the last year, 25 hours in the last three months and 2:40 h in the last month during a flight on 13 January 2010 with the same crew as on the accident flight. His duty times complied with the requirements of DGAC Operating Circular 16B¹⁶.

In the last six months he had been on five nighttime and six daytime training flights.

There is no record of any previous accidents or any reports critical of his training or flight activity.

Captain's training

Between July and September 2007¹⁷, he took the single-pilot¹⁸ AW139 type rating and instrument flight course at AgustaWestland's training facilities in Italy. He took the ground course and obtained a grade of 86.7%, the minimum being 75%. He also received 14 hours of simulator training in VFR (visual flight rules) conditions and 6 hours in IFR (instrument flight rules). He also flew a 3.5-hour training flight and a proficiency flight lasting just under two hours. All of these hours were flown as part of the type rating course.

Between October and November 2007¹⁹ he took the operator's SAR course as a captain.

In December 2008 he took the SA365 type rating course.

On 30 and 31 August 2009, he took the operator's proficiency test and renewed his instrument flight and AW139 type ratings at AgustaWestland's simulator in Italy. Listed alongside these checks in the captain's log book was an entry for the MCC (multicrew cooperation) course.

Captain's profile

He had been a military pilot and was an instructor at the Armilla Base. His colleagues regarded him as a methodical professional, rigorous with procedures and with flight

¹⁶ DGAC Circular 16B is the regulation in Spain that is applicable to flight time limitations, maximum duty times and minimum rest periods for crews not involved in commercial airplane transport.

¹⁷ 2 to 13 July 2007: AW139 Type rating ground course (theory course).

27 September 2007: AW139 VFR/IFR type rating.

¹⁸ The AW139 helicopter is certified for a single pilot, though the flight manual requires a minimum crew of two pilots for SAR activities. The rating course for multi-pilot helicopters includes special requirements for a multi-pilot environment, and specifically covers aspects such as crew resource management, adequate supervision to remain aware of helicopter operations, setting priorities and decision making.

¹⁹ 9 to 11 October 2007: ground portion of SAR course at the base in La Coruña.

29 October to 18 November 2007: practical portion of SAR course at the base in Valencia.

safety rules. He was considered one of the finest pilots to have passed through the base. He was not authoritarian in his relationships with his students and was able to delegate. He was on inactive military duty.

The colleagues who knew him through his work at INAER HELICÓPTEROS OFF-SHORE described him as being somewhat introverted but who got along well and who cherished his family. Professionally he was regarded as a pilot who liked to follow procedures and who held rigorous, long and detailed briefings. His family lived in Granada but they had a summer home in Retamar, near Almeria, where he stayed while he worked. The night before the accident he had slept there and, as he told his wife over the telephone, he had slept very well and was rested.

1.5.2. *Copilot*

Copilot's experience

The 43-year old copilot was a native of New Zealand and had lived in England. His native tongue was English. He had a JAR-FCL commercial pilot license, AW139 and IFR ratings and a medical certificate, all valid at the time of the accident. He had been with the company for one year.

He had a total of about 1,200 flight hours, including:

- 824 h on the R22 (591 as an instructor). Single-engine piston.
- 243 h on the R44 (115 as an instructor). Single-engine piston.
- 100 h on the AW139. Twin turboshaft.
- 31 h on the AS355. Twin turboshaft.
- 9 h on the B206. Single turboshaft.
- 5 h on the B222. Twin turboshaft.
- 1:50 h on the Eurocopter AS350. Twin turboshaft.

Of the 1,200 h, most had been in visual daylight conditions. He had 44 h in nighttime visual conditions and 47 h in IFR. He had a total of 35 h of nighttime SAR flights.

He had flown 104 h in the last year, 23 h in the last three months and 9 h in the last month. He had flown twice on 16 January and on 13 January he flew with the same crew as on the accident flight. His duty times complied with the requirements of DGAC Operating Circular 16B.

In the last six months he had been on nine nighttime and two daytime training flights.

There is no record of any previous accidents or any reports critical of his training or flight activity.

Copilot's training

In January 2009²⁰ he took the ground course for the AW139 type and instrument flight ratings at AgustaWestland's training center in Italy. He only took the ground course, receiving a grade of 91.7%, the minimum being a 75%. Unlike the captain, he did not perform the remaining activities (simulator training, training flight and proficiency test) required for the AW139 type rating at AgustaWestland. Of these three activities, the training flight and the proficiency test were administered four months later, in May of 2009²¹, by the company at its Bilbao base. He did not do the simulator training²². He did not fly from January until May.

In June 2009²³ he took the SAR ground course and in August 2009²⁴ in Santander he completed the practical portion of the SAR course as the second pilot.

He had not taken the MCC (multicrew cooperation) course.

Copilot's profile

Before being hired by INAER HELICÓPTEROS OFF-SHORE in January 2009, he had held various jobs at small helicopter and aerial work companies. He had been an instructor and had flown on photographic and mountain missions. He had done jobs involving the implementation of aerial security and logistics systems. He had been an English teacher, marketing director and sales team coordinator, having been named "1988 salesman of the year". He had worked almost three years as a bank administrator. He received his commercial pilot license in May 2006.

Pilots who had flown with him regarded him as receptive, involved, constructive and willing to learn. One of his instructors described him as someone who put forth ideas and who asked if he did not understand. On a personal level they regarded him as friendly, someone who got along with his colleagues.

²⁰ 12 to 23 January 2009: AW139 type rating ground course.

²¹ 29 April to 4 May 2009.

²² INAER had a partnership agreement with AGUSTA to teach the type rating course, and so the way in which the course was given to the copilot is allowed by the JAR-FCL. JAR-FCL regulations require doing training on a helicopter even if a simulator is available.

²³ 9 to 12 June 2009.

²⁴ 17 to 24 August 2009.

In the opinion of several colleagues, he spoke Spanish well and his level was sufficiently high to communicate, though in flight his Spanish was a weakness as it posed certain difficulties. According to comments obtained during the investigation, he had proposed at the Almeria base that communications involved in flight operations be in English, which upset some of the captains.

With regard to the accident flight, according to his wife, he was happy to be flying with that captain because he was the kind of pilot who made sure to train his copilots and “let them fly”.

1.5.3. Crew’s flight activity in January

The crew’s flight schedule for the month of January is shown in Table. The captain had been on duty for 14 days with only one rest day. The copilot had been on duty for 14 days straight. Days off are shown in blue, duty days in red and travel days in yellow. Travel days are given so that itinerant crews, which are not stationed at a base, can travel to that base. The crews are paid for travel days. Both the captain and copilot were “itinerants”, though the two had been stationed in Almeria for practically half a year.

Captain							Copilot						
L	M	X	J	V	S	D	L	M	X	J	V	S	D
				1	2	3					1	2	3
4	5	6	7 travel	8	9	10	4	5	6	7 travel	8	9	10
11	12	13 train	14	15	16	17	11	12	13 train	14	15	16	17
18	19	20	21 accid				18	19	20	21 accid			

Table 2. Flight crew schedule for January 2010

1.5.4. Flights together as pilot-copilot

The pilot and copilot had flown together as a crew six times before. The last flight before the accident had been on 13 January 2010, when they went on a training flight lasting 2:40 h. They had first flown together on 25 August 2009.

1.5.5. *Winch operator*

The winch operator²⁵, 49, had been working at the company for 17 years and had 1830 flight hours. He had 1,800 h of SAR experience and 50 on the AW139. He had taken the SAR course in July 2007. In the last six months he had flown on 4 daytime and 5 nighttime training flights.

1.5.6. *Rescue swimmer*

The rescue swimmer, 33, had been working at the company for 3 years and had 290 flight hours. He had 290 h of SAR experience and 94 on the AW139. He had taken the SAR course in September 2007. In the last six months he had flown on 7 daytime and 7 nighttime training flights.

1.6. **Aircraft information**

1.6.1. *General information*

The AgustaWestland AW139 is a twin turboshaft transport helicopter with a 5-blade main rotor, a 4-blade tail rotor and retractable gear. It has a type certificate issued by the European Aviation Safety Agency (EASA). Although the helicopter is certified for a single pilot, Section 1 of the Flight Manual, Limitations, of supplement 69²⁶ specifies the minimum crew for SAR operations as being two pilots.

Helicopter EC-KYR, serial number 31228, was delivered after manufacture to its owner, SASEMAR. The airworthiness certificate was issued on 22 May 2009 and it was registered in Spain on 25 June 2009 (on March 2009 the helicopter had a provisional registration). At the time of the accident it had a total of 384:35 hours and it had been operated by INAER HELICÓPTEROS OFF-SHORE since its manufacture.

The helicopter was powered by two Pratt & Whitney PT6C-67C engines. Engine number 1, serial number PCE-KB0469, was manufactured on 25/09/2008. Engine number 2, serial number PCE-KB0467, was manufactured on 15/09/2008. Both were installed new on the helicopter and had a total of 384:35 flight hours each, the same as the helicopter.

Its insurance certificate was valid and in force at the time of the accident and it was part of the fleet of aircraft authorized by Spain's Aviation Safety Agency

²⁵ All winch operators are rescue swimmers.

²⁶ Supplement 69 to the Flight Manual: *4-axis enhanced FD with SAR MODES (phase 5)*.

(AESAs) to conduct emergency operations as part of INAER HELICÓPTEROS OFF-SHORE's operations.

According to the aircraft logbook, it went into service in late May 2009 and had been operated mainly out of the Almeria base.

The aircraft's last flight before the accident had been the day before, Thursday, 20 January, and consisted of a local daytime flight around Almeria lasting two hours, after which it was refueled with 1,000 liters of fuel.

1.6.2. Configuration of helicopter EC-KYR: FD, AP and SAR modes

The helicopter was configured to conduct SAR operations. It featured a 4-axis enhanced Flight Director that was normally coupled to the autopilot (AP). The FD provides guidance references which the AP executes via actuators as long as the FD is coupled to the AP. The FD may or may not be coupled to the AP. When decoupled, flight is said to be in manual mode. When coupled, the AP provides automatic flight control about the helicopter's three axes and to the collective control. The FD modes that include control of the collective feature a safety function called Fly-up, which is explained in Section 1.6.4.

The FD version installed on EC-KYR was the most complete and included the SAR modes, which has functions specifically developed for search and rescue activities. The SAR modes allow the helicopter to descend (TD – transition down), descend to hover (TDH – transition down to hover), transit to a hover at a reference point (MOT – mark on target), climb from a hover (TU – transition up), all of them automatically. It also features certain winch operator adjustments (WTR – winchman trim).

When MOT or TDH SAR modes is selected, the landing gear warnings (acoustic and LANDING GEAR visual warnings) are inhibited so as not to interfere with operations.

1.6.3. Maintenance records

The aircraft had been maintained in accordance with an approved maintenance program. Its last 25- and 50-hour inspections had been on 7 January 2010 and 15 December 2009, respectively.

The aircraft had six deferred maintenance items at the time of the accident described below. The operator had not devised a minimum equipment list (MEL) adapted to SAR

operations requirements²⁷ and relied on the manufacturer's master minimum equipment list (MMEL)²⁸. As regards the MMEL, which is not mandatory:

- Three of the deferred items involved optional equipment, and were therefore not affected by the MMEL.
- On 20 November 2009, the CHECK HEIGHT acoustic warning associated with the decision height was logged as inoperable. This warning is associated with a specific software version, and was thus not affected by the MEL. According to information provided by the manufacturer, however, in order for the DH warning not to function, the two radio-altimeters must be inoperable.
- On 25 November 2009, a flicker in the copilot's MFD was logged in the maintenance records. The MMEL did not allow for nighttime operations with one of the copilot's screens inoperative. While the maintenance record utilizes the word "flicker", the fact is that in all of the flights, both the accident flight and those previously recorded on the FDR, the MFD was turned off and the PFD was placed in composite mode, meaning that crews operated as if the MFD were inoperative. Assuming that the flickering started during the flight, once it becomes inoperative in flight and it switched off, the Flight Manual requires²⁹ that copilot to hand the controls to the pilot.
- On 4 December, an entry was made that the breaker for the cockpit lights opened in flight. The MMEL allowed for nighttime operations as long as the discrepancy was resolved within 10 days, that is, before 14 December 2009.

1.6.4. *Low-altitude protection systems on the helicopter*

As configured, helicopter EC-KYR included the following low-altitude protection warnings and systems (figure 5):

- The following warnings associated with decision height (DH):
 - A visual warning in the shape of a black rectangle that appears on the artificial horizon when the helicopter descends through DH+100 ft.
 - If the helicopter continues descending to DH or lower, the letters MIN are shown inside the black rectangle.

²⁷ R.D. 1762/2007 established the requirement to have a MEL for civil aircraft used for commercial air transport and for aerial work in Spain. Subsequently, on 24 September 2009, AESA's director issued a letter allowing aircraft engaged in aerial work to operate without a MEL.

²⁸ The MMEL affects the equipment related with airworthiness and operational requirements. Additional or optional equipment is not affected by the MMEL.

²⁹ Display unit malfunctions, page 3-318.

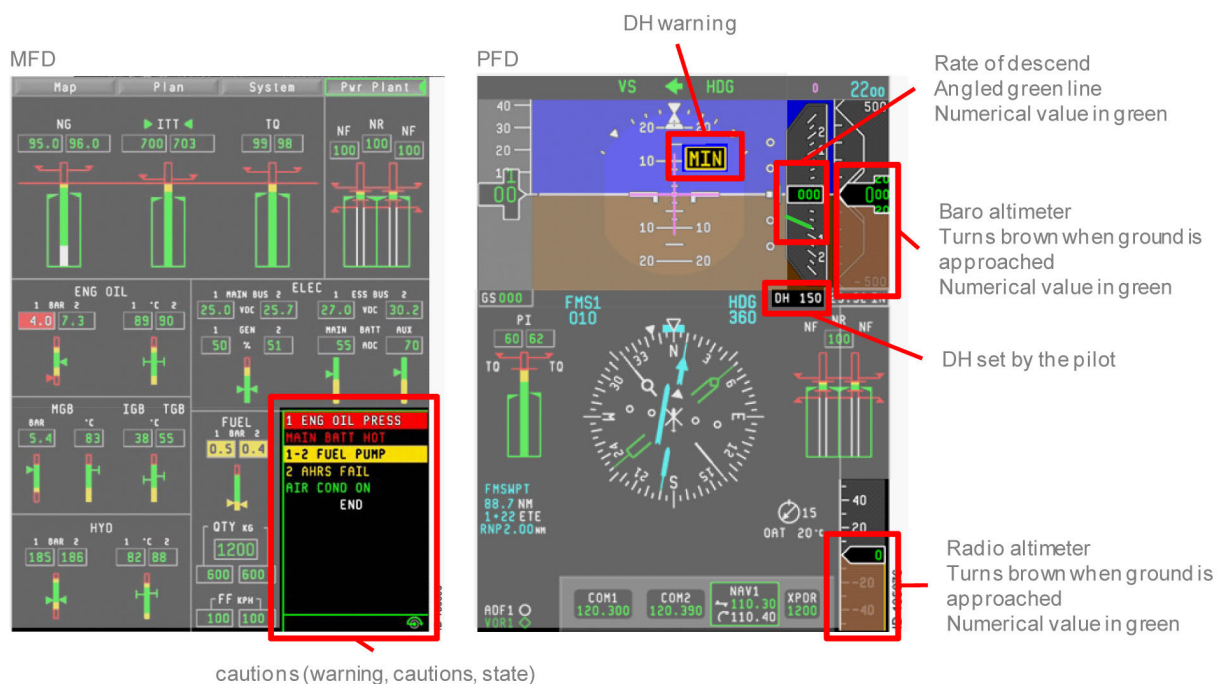


Figure 5. Display of altitude related warnings and information

– An aural CHECK HEIGHT warning when the helicopter is descending at or below DH. This warning is activated at the DH of the pilot flying. It is this warning that had been logged as inoperative since 20 November 2009 but which worked on the accident flight.

The value of DH is selected by each pilot and is shown in one of the flight displays (PFD). Its value is set using a wheel on the instrument panel to the left of the display.

- Associated with an altitude of 150 ft:
 - An aural LANDING GEAR warning preceded by a dual chime sounds, is activated when the landing gear is not extended and the helicopter is descending through 150 ft. For the AW139, sounding the warning at this height allows the gear to be lowered before touchdown under normal speed and descent rate conditions (between 400 and 600 ft/minute).
 - A visual warning that displays the words LANDING GEAR on the MFD.
 - A master caution light (MCL), which is a yellow light above the flight displays.
 - An aural ONE FIFTY FEET warning³⁰ that sounds when the helicopter is at an altitude of 150 ft. The warning sounds even if the gear is down, providing the crew with an additional ground proximity alert. The LANDING GEAR warning has priority over the ONE FIFTY FEET warning.

³⁰ The aural ONE FIFTY FEET can be inhibited by the crew using the AWG switch located on the pedestal. This action it is not included on the procedures.

All of these warnings functioned on the accident flight.

- Associated with the FD modes that control the collective (collective safety function fly-up):
 - During a descend, the helicopter climbs automatically to a minimum altitude when a safety altitude is exceeded. This function is active whenever an FD mode is engaged that includes control of the collective. The minimum altitudes vary depending on the FD mode.
 - An aural ALTITUDE, ALTITUDE warning when the minimum altitude is crossed.
 - A visual warning in the shape of a yellow rectangle with the letters HTLM in black on the artificial horizon when the minimum altitude is exceeded.

None of these functions or warnings worked at the time of the accident since none of the FD collective modes was engaged.

1.6.5. *Altitude related warnings and information displays*

Each pilot has two screens on which information is shown, called the PFD (primary flight display) and the MFD (multifunction display). The PFD includes all of the flight and navigational information (altitude, speed, horizon, FD modes, etc.) and the MFD includes all the information detailing the status of the aircraft (danger and caution warnings, systems status, etc.) and can display, if selected by the crew, detailed navigation information.

PFD: The altitude indications consist of two vertical strip displays that include a representation of the ground plane on both baro-altimeter and radio-altimeter that progressively moves a vertical brown strip topped with an amber bar in proportion to height as the helicopter nears the ground. The altitude is shown in the center of the bar in green digits. The descent rate is shown using a green pointer on a vertical bar located between the horizon and the barometric altitude. The visual warnings associated with the DH and the fly-up function are displayed in the top half of the artificial horizon.

MFD: The visual danger or caution warnings, such as the LANDING GEAR visual warning, for example, are shown at the bottom right of the display.

1.7. **Meteorological information**

Information relevant to the meteorological conditions throughout the flight was obtained from the following sources:

- AENA, via the METAR reports for the Almeria and Malaga airports.
- AEMET, via infrared satellite images, cloud cover maps, surface analysis maps and winds and humidity aloft maps of the impact site.
- The CVR, via the comment made by the captain 11 minutes regarding sunset and the wind references provided during the exercises.
- The survivor's statement.

This information indicates that the flight took place on a dark night without any adverse weather phenomena. There was a gibbous moon and the stars were not visible. Winds on the surface and aloft were calm, it was mostly cloudy with no signs of convective activity that could give rise to turbulence and the relative humidity was low.

1.8. Aids to navigation

Not applicable.

1.9. Communications

During the accident flight, aircraft EC-KYR was in radio contact with the Almeria control tower, with the Salvamar Denévola, with the SAR tower in Almeria and with the rescue swimmer during the last exercise.

On the return flight to Almeria after the completion of the last exercise, the aircraft was in contact with the Salvamar Denévola and with the Almeria control tower. The communications were handled by the copilot and involved a total of seven exchanges, the first two with the Salvamar Denévola and the last five with the control tower:

- Between 20:14:05 h and 20:14:19 h (14 seconds), with the aircraft departing from a hover (at an altitude of 200 ft and a GS of under 50 kt), the first contact with the Salvamar took place to sign off.
- Between 20:14:29 h and 20:15:14 h (45 seconds), with the Almeria control tower requesting and acknowledging instructions to land in Almeria.
- Between 20:15:19 h and 20:15:28 h (9 seconds), with the Almeria control tower, which asked if they wanted the landing lights or if the taxi lights were sufficient.
- Between 20:15:51 h and 20:16:02 h (11 seconds until impact), with the Almeria control tower which asked if they wanted to refuel upon arrival.

Figure 6 shows the amount of time devoted to communications on the return flight. Those with the Salvamar are shown in green and with ATC in gray. The solid lines are the copilot's transmissions and the dashed lines are the transmissions from the Salvamar and ATC to the aircraft.

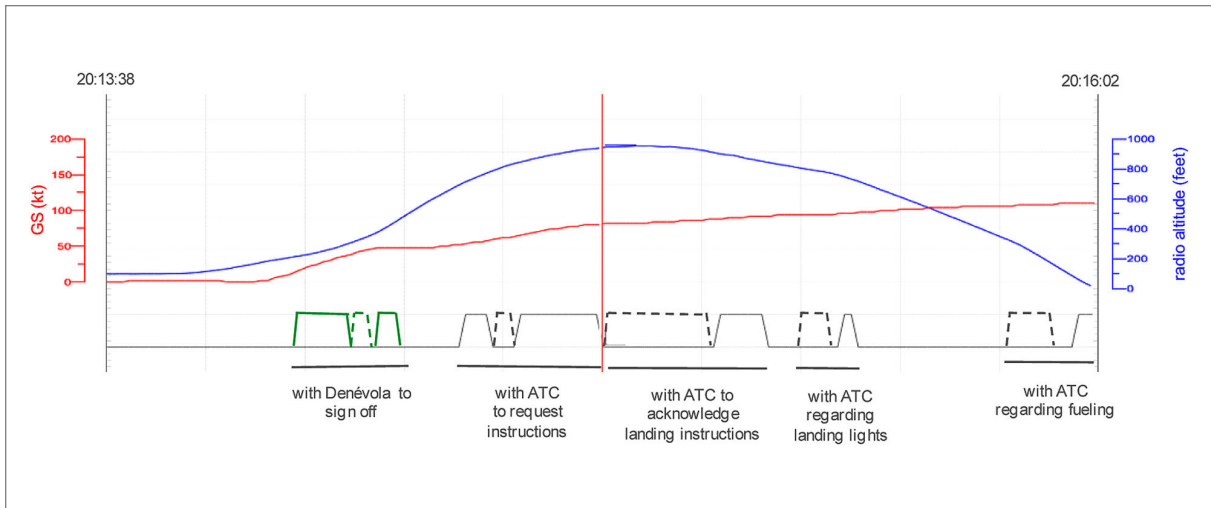


Figure 6. Time devoted to communications during the return flight to Almeria

1.10. Aerodrome information

At the conclusion of the exercise, aircraft EC-KYR received instructions from the control tower to land on runway 08 at the Almeria Airport. The expected flight path should have been one of the two shown in figure 7 in which, after climbing to a safe altitude, the crew should have initiated a turn to line up with the runway. Whether the turn was to the right or left depended on the amount of time needed to configure the helicopter for landing. A turn to the right would have allowed more time.

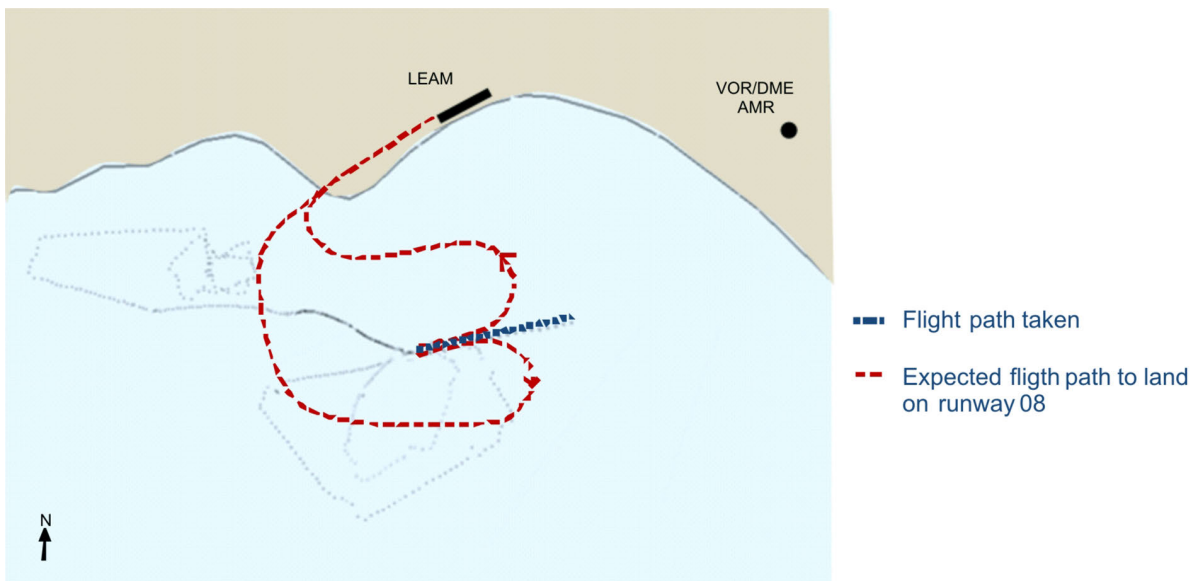


Figure 7. Expected return path to Almeria

1.11. Flight recorders

The helicopter was outfitted with a combined Penny&Giles recorder, P/N D51 615-102, which recorded both flight parameters and voices in the cockpit. This device was recovered on 1 February 2010 at around 22:00 h after having been submerged in 91 m of water for 11 days.

After it was removed from the helicopter, it was kept in fresh water and taken to the facilities of the United Kingdom's Air Accident Investigation Branch, where it was opened. Although there was no external impact damage and the electrical connections were intact, the water pressure to which it has been subjected had affected the memory, requiring that the unit be washed and dried.

The flight parameters were properly downloaded and validated. The nominal length of the recording is 25 hours and, in this case, the recorder yielded 25 hours, 16 minutes and 51 seconds of data.

The cockpit voice recorder channels could not be properly downloaded at the AAIB's facilities, so they were taken directly to the manufacturer for processing. All of the CVR's channels were eventually recovered, allowing investigators to access the communications from the last two hours of the flight, and specifically those from the time of the accident.

1.11.1. First exercise

On the flight out from Almeria, the captain reminded the crew of the exercises to be carried out. The atmosphere was good, respectful and cordial. The language used by the captain was formal but relaxed. The copilot's communications were respectful and more formal than the captain's.

The approach to the first ship was flown by both pilots in manual, with the captain as the pilot flying to 200 ft, and the copilot from 200 ft until the end of the maneuver.

The approach was rectangular in shape (figure 1). The helicopter started 500 ft above the ship at a speed of 120 kt. Of the 21 items on the SAR APPROACH checklist that the crew had onboard, numbered 1 to 21 (items were not numbered), 12 were completed off in the following order: 1-9-3-2-5-20-4-10-19-16-3-17. When at a distance of 3 NM they were at 300 ft and 100 kt, at 2 NM away they were at 300 ft and 90 kt and at 1 NM away they were at 200 ft and 65 kt.

The DH values had been set prior to takeoff and were 200 ft for the captain and 0 for the copilot. They remained at those values for half an hour until the captain's DH was changed from 200 ft to 120 during the approach, at the captain's request following the

sounding in the cockpit of the CHECK HEIGHT warning associated with the DH. The captain's comment at that time was, "correct that altitude for me, please, set it at 125". The copilot changed not only the captain's DH but his own, setting both at 120 ft.

Throughout the approach the copilot was asking questions about navigation, modes and courses. The captain answered his questions and explained how to interact with the winch operator when passing him the controls. The captain reminded the copilot not to forget to execute a "SEA APPROACH", and later asked if he had completed it. During the descent the captain told the copilot not to forget to set "the 102", concerning one of the items on the list. During one of the turns the captain pointed out that he had turned 30° too far.

Control was transferred with the words "you have the controls". The captain became the pilot not flying and supervised all of the copilot's actions at all times. While executing one of the checklist items as the PNF, the captain apologized for almost closing the BUS TIE instead of setting NR at 102% ("sorry, I'm in rare form, I was going to close the BUS TIE"). During the winch operations the winch operator also gave indications to the copilot. The wind direction was not ideal and the copilot had trouble maintaining altitude and position above the ship while hovering. They climbed when the captain finally decided to end the maneuver. During the climb, the captain continued to monitor the copilot and give him instructions: "Don't overshoot it, you don't have three greens yet"³¹, "come on, get the helicopter moving", "let's go that way".

The departure was executed in manual and of the 18 items on the SAR DEPARTURE list, three were completed in the following order: 2-3-6. While climbing to 500 ft, the CLIMB list was not performed and the conversation throughout the climb focused on the previous maneuver and on the problems the copilot had encountered.

1.11.2. *Repeat of first exercise*

The copilot remained as the pilot flying throughout the exercise. The DHs were not changed and continued to be set at 120 ft for both pilots. The SAR maneuver was started 500 ft above the vessel at a speed of 100 kt. At a distance of 3 NM they were at 300 ft and 80 kt, and at 2 NM they were at 200 ft and between 50 and 60 kt. The maneuver traced out a rectangular shape and the crew performed items 1-10-16-19-2 on the approach checklist in that order. During the check of the baro-altimeter and radio-altimeter (item 2 on the approach list), the captain used the expression "1023 because that way the radio-altimeter and the DH are closer". Before starting the coordination maneuvers with the winch operator, the captain asked the copilot, "Should I set the DH or do you prefer to do it in manual?" During the descent to the ship, the

³¹ The expression "three green" refers to checking that the baro-altimeter, the radio altimeter and the vertical speed show a positive rate of climb.

LANDING GEAR and ONE FIFTY FEET acoustic warnings sounded once, and during the exercises above the ship, which were performed at 150 ft, each warning sounded an additional seven times.

The flight crew coordinated with the winch operator, in keeping with the guidelines in the SAR manual. All of the actions were monitored and the prescribed call-outs were made.

The climb was done in manual, as had the entire exercise. Items 8-1-12 on the SAR DEPARTURE checklist were checked using terms such as "I'm looking for three green". The captain set an altitude of 500 ft and the course for the transit flight.

The captain continued to monitor and instruct the copilot while maneuvering above the ship and during the climb. No items on the CLIMB checklist were performed, though the problems encountered during the exercise were analyzed.

1.11.3. *Flight toward the Salvamar exercise area*

The flight to the exercise area was performed with the copilot as the pilot flying. During this phase the copilot admitted having made a mistake, "oh, I overshot it, I'm clueless", though it is not known what he was referring to. During this leg, the captain contacted Almeria tower to inform them of their new exercise area and the operating altitudes. During this transmission he reported that they were proceeding to point W. After ending the transmission, he realized that it was the other way around, they were heading toward point E. The captain also reviewed with the winch operator the nautical terms to be used with the Salvamar: "the wind has to be coming from the Salvamar's starboard tack, right? It's just that I'm not used to port and starboard and it's better to figure this out now so we don't stick our foot in it...". The captain also made sure that the procedure to be used regarding the use of spotlights when the swimmer was in the water was understood by everyone.

He kept track of the times throughout the flight and instructed the copilot on what to do: turns, altitudes and speeds. At one point while waiting, the captain told the copilot, "let's review some basics, ok?" To which the copilot replied, "yeah, that's ok, um... I like the manual too, whatever".

1.11.4. *Second exercise*

The approach to the vessel was done with the copilot as the pilot flying. The pattern was initiated at 500 ft on the downwind leg. When at a distance of 3 NM they were at 300 ft and 70 kt, at 2 NM away they were at 200 ft and 60 kt and at 1 NM away they were at 200 ft and 60 kt. They checked items 1-2-3-4-5-6-7-8-9-10. The checklist

was interrupted by a transmission from the Salvamar, and the captain continued the list with items 11-12-13-14-20-15-16-18.

The captain's decision height was changed to 40 ft, while the copilot's remained at 120 ft. The LANDING GEAR and ONE FIFTY FEET acoustic warnings sounded during the approach.

The captain corrected the copilot's courses, speeds and altitudes throughout the transit, anticipated the task sharing for winch operations reminding the copilot to take charge of communications and reported an erroneous course to the Salvamar, immediately identifying the mistake and saying "it's backwards, I always get it wrong, I said 060 and I need you to go to 120". The captain took control of the aircraft for the winch operations but initially continued handling communications with the Salvamar and the tower. Despite being the pilot flying, he carried out actions that he should have asked the copilot to do, saying, "I've already done it, the next time I'll ask you, you're right". The winch operations were carried out with constant acknowledgments of the winch operator's instructions and the copilot monitored the fuel remaining, advising the captain to watch the engine power.

The departure from hover was made in Transition Up mode and called out by the captain. Once the winch operator reported the cabin clear and the door closed and latched, the copilot established contact with the vessel to tell its crew the new course for the next exercise. The captain corrected the copilot during his transmission to the Salvamar, telling him to use the term hover for the ships. No items on the SAR DEPARTURE checklist were performed and no crosschecks were made during the climb.

1.11.5. *Third exercise*

The third exercise consisted of two transits, one to drop off the swimmer and another to move away and return to search for him. The pilot flying during the exercise was the captain.

The first exercise traced out a rectangular shape and the second an elliptical one. The first circuit was done in manual at 300 ft and the approach parameters were as follows: they were at 300 ft and 80 kt at 3 NM, at 200 ft and between 60 and 70 kt at 2 NM and at 125 ft and 60 kt at 1 NM. The LANDING GEAR and ONE FIFTY FEET warnings sounded. During this approach the copilot's decision height was changed from 120 to 70 ft; the captain's was kept at 40 ft. The items on the SAR APPROACH checklist were performed in the following order: 16-2-1-9-3-6-5-12-5-20-4-14-15, with item 5 being performed twice.

The captain continued to instruct the copilot on the need to use a specific radar mode and on courses, and performed some of the copilot's actions. After lowering the

swimmer into the water and asking the Salvamar to turn off its lights, the captain said they were flying 5 NM away, a value that was changed to 3 and 2 NM. The departure from hover was done in Transition Up mode and was interrupted by a premature control input by the captain. The helicopter started to decelerate and the copilot, who realized that something was happening, asked him, "What's going on? What are we doing now?" The captain instructed him to engage some FD modes and explained to the copilot that "I got mixed up, my hand got away from me", to which the copilot replied, "I didn't know what you were doing just then, I was a little..."

On the second circuit, the captain decided that 2 NM was enough when they decided to return for the swimmer. They were at an altitude of 200 ft and 80 kt. They were unable to establish radio contact with the swimmer due to a problem with his equipment, which led to some tension in the cockpit. The swimmer used flares and was eventually located. The return flight to rescue the swimmer did not follow any of the courses selected by the copilot since the maneuver was cut short. This resulted in the copilot being out of the loop for over two minutes, without knowing what segment of the circuit they were in. "It's just that you did the circuit and I don't know where you changed...", "but we're not on downwind, the wind is from the right". They did items 19 and 21 on the SAR APPROACH list. During the descent the LANDING GEAR, ONE FIFTY FEET and LOW SPEED warnings sounded.

The operation to raise the swimmer onboard with the winch was carried out utilizing established checks and acknowledgments. The operations with the spotlight on lasted 10 minutes.

1.11.6. *Final climb: return to Almeria*

The last climb was initiated after the winch operator reported "I'm going to close the door". The captain anticipated the report of the door being closed and latched and disengaged the FD from the autopilot a second before said report was made. The departure was done in manual. Items 1 and 8 on the SAR DEPARTURE list were completed. The tone of the captain's voice, which had been energetic throughout the previous flight, became much more muted, less blunt and serious. The copilot, after unsuccessfully attempting to keep up with the events of the flight, proposed signing off from the Salvamar immediately and from that moment on until the impact, devoted himself to communicating with the Salvamar and with the control tower and to preparing for the approach.

Winch operator: *I'm closing the door, OK?*

Captain: *All right*

Disengaging HOVER and RHT

Winch operator: *Door closed and latched with cabin clear, whenever you want*

Captain: *Very well*

Winch operator: *Turning off winch spotlight*
Captain: *Applying power for three greens*
Copilot: *Your heading is set*
Captain: *I don't have anything. One, two, three*
Copilot: *Transmitting to Denévol, ok?*
Captain: *Tell them thanks, we're leaving*

When the pilot finished talking with the vessel at 20:14:21 h, the captain adjusted rotor speed from 102% to 100%, told the copilot to call the airport and said that he would be doing the landing. "I'm landing it, ok? I haven't done a landing in ages". Almeria TWR gave them the landing information, which the copilot acknowledged, and the captain modified the QNH pressure, as recorded on the FDR.

When the transmission with the landing instructions was finished, ATC called them again "Do you want the lights on 08 or are the taxi lights enough?" The captain, who was monitoring the transmission, anticipated the copilot's question and gave an answer to the copilot. At that time they were at 750 ft and descending. The captain requested the pre-landing checklist:

Captain: *Ok, let's do a pree*
Copilot: *A pre-landing, right?*
Captain: *Yes, a pre-landing please (tired voice)*
Copilot: *OK (indicates that he has the list)*
Approach briefing, what type of landing? (First item on the list)
Captain: *Sorry? (Yawn) Type category bravo*
Copilot: *Bravo, ok*
Captain: *Thirty fifty*
ATC: *Helimer 07, will you want to refuel so I can notify the tanker?*
Copilot: *What time is it?*
Captain: *Yes, yes, if you can fit us in (Master Caution, LANDING GEAR and ONE FIFTY FEET warnings start sounding), eight fifteen*
Copilot: *Affirmative, we want to refuel Helimer 07 (impact and transmission interrupted)*

At the start of the captain's final comment, the copilot would have had on his display the warning associated with his DH, a black rectangle (at 170 ft), which would have immediately appeared on the captain's display (at 140 ft). Due to the descent rate and to the priority of the landing gear and 150-ft warnings over the DH, the DH acoustic warning never sounded, since the 150-ft warning ended half a second before impact.

The engine parameters indicate that they were synchronized until the end of the flight. The reduction in torque to 30% at the moment of impact was reflected in the remaining engine parameters (temperature, fuel flow and rpm's), whose behavior was consistent with said reduction.

1.12. Wreckage and impact information

1.12.1. *Location and recovery of the wreckage*

The search for the helicopter and its crew and their recovery were carried out by the Spanish Maritime Safety Agency (SASEMAR), a branch of the Ministry of Development.

The efforts to locate the wreckage begun on the day of the accident and relied on the signal transmitted by the beacon on the helicopter's FDR, the fuel slick, structural components that floated to the surface (rafts, helmets, doors and the winch operator's vest) and the last radar returns. The emergency locator transmitter (ELT) on the helicopter did not function, but the transmitter on the left raft and the swimmer's personal transmitter did. The helicopter was found at coordinates 36° 46.6145' N 002° 21.1665' W, approximately 4.5 NM south of the Almeria Airport at a depth of 91 m (item (10) in figure 2).

The recovery was carried out in three phases:

- The first phase was devoted to the recovery of the dead crew members. It was performed on site at a depth of 91 m once it was confirmed that the three victims were still in the helicopter, and relied on the use of a remotely-operated vehicle (ROV) and divers. The crew was recovered on 24, 25 and 28 January 2010.
- The second phase involved the recovery of the helicopter. On 30 January, readings were taken to verify the condition and position of the helicopter before recovery efforts were started. The left and right main landing gear were used as anchor points to raise the helicopter, as they appeared to be intact and accessible. On 31 January an effort was made to raise the helicopter directly from the impact site, though the decision was later made to move the helicopter to a depth at which divers could work without restrictions and could assist with the operation. On 1 February 2010, with the wreckage at a depth of 23 m, an attempt was made to raise it, during which the anchor points on the main gear failed. The wreckage was submerged again and, with the aid of divers, slings were placed around the main and tail rotors and the fuselage. The helicopter was raised to the SASEMAR vessel Clara Campoamor, placed upright and washed down with fresh water to prevent corrosion. The FDR was removed and placed in fresh water. In the early morning of 2 February, the helicopter was transported to a hangar at the Ocaña aerodrome.

1.12.2. *Wreckage inspection*

On 23 March 2010, with the support of the manufacturer AgustaWestland, it was conducted a full structural inspection of the helicopter wreckage at the Ocaña aerodrome. This inspection generally served to confirm the strong high-speed frontal impact with the helicopter in level flight. The doors had blown out, indicative of high water pressure

entering the helicopter from the front toward the rear and then outward. The damage to the main rotor was consistent with the sudden stoppage of the rotor under power. The aft fuselage and the tail cone were bent upward and to the right, resulting from high inertial loading as a consequence of the impact and of the tail rotor.

The findings of this inspection rule out any structural problems prior to impact and are consistent with the recorder data and with the findings of the engine inspection.

Forward fuselage

The nose compartment with all the avionic equipments, nose landing gear, cockpit interseat console, front floatation, collective torque tube, parts of the cabin floor and a large number of wiring and cables were together in a large debris pile. The structure of the cockpit did not highlighted significant parts separation but was evident a transversal torsion appreciable on the right side. The cockpit console showed severe distortions and impact damages on the right side and was detached from the cockpit structure. The overhead panel was ripped from the cabin structure showing impact damages in the front part. The canopy showed a transversal fracture: the left windshield did not presented any damage as the upper windows, instead the right side wind shield was crashed in the upper right corner and the upper window was missing. The right seat showed an overall integrity of the seat structure although with evidence of permanent deformation. The flight controls have been found broken but still attached near by the seat (cyclic, collective and pedal). The left seat showed significant structural damages and deformations as the remained attached floor without any flight controls.

Center fuselage

The center fuselage suffered extensive damages on the lower part. The cabin forward floor was missing back to the main landing gear, both of which were in the up position. The left and right side fuselage side walls were detached from the structure; in particular the right side showed significant structural deformations. The right bubble window was no more installed.

Main rotor

The main rotor pylon, despite the heavy impact suffered, was still connected to upper deck trough the four mounting rods and anti torque plate. The engines have been found connected to the airframe and the output shafts to the main gear box. The rotating flight controls were found damaged but still connected. Main rotor blades were damaged by the impact and the tip caps detached have been recovered floating. The main rotor head showed damages consistent with a powered rotor sudden stoppage.

Rear Fuselage

The rear structure suffered compressive damages in longitudinal/vertical direction and a torsion deformation.

Tail section

The tail section suffered extensive compression/bending deformation. Panels' deformations and failure were consistent with up-right bending loads. The rearward tail section was almost totally separated from the forward and was completely detached during the recovery operations. The tail rotor drive shaft failed mainly for bending loads in accordance with rearward right tail boom detachment.

Tail rotor

The tail rotor connected to the gearbox still attached to the fin appeared without significant damages.

Flight controls

The fixed flight controls system was broken in several locations as result of airframe damages and deformations, mainly in the forward fuselage area. The continuity and connection were positively verified visually including the linear actuators, mixing unit and main rotor servo actuators connections. The tail rotor controls chain was verified in some parts due to the damage during the recovery operations.

1.12.3. *Engine inspection*

On 2 and 3 March 2010, the two PT6C-67C engines on the helicopter were disassembled and inspected with the help of the manufacturer, Pratt and Whitney.

Both engines were structurally intact. When they were inspected, they were starting to show signs of corrosion due to having been submerged in sea water. The main rotor rotated freely and the bearings did not exhibit any problems. The accessory gearboxes on both engines rotated and there was continuity in the gears to the compressor rotor. Neither engine's turbine section exhibited significant mechanical damage. Friction marks at the ends of the rotor blades on the first compressor stage and on the first power turbine stage on both engines indicated that the engines were turning at the moment of impact.

The findings from the inspection indicated that the engines were turning and generating power at the time of impact. No evidence of any mechanical problem was found indicative of improper operation before the impact.

1.12.4. *Fuel analysis*

Samples of JET A-1 fuel were taken from refueling unit n.º 371 at the Almeria Airport, which was the last to refuel helicopter EC-KYR. These samples were analyzed at the laboratories of CLH (Compañía Logística de Hidrocarburos) and INTA (National Institute for Aerospace Technology).

The results of the tests and analyses confirmed that the fuel complied with specifications and did not show any signs of biological contamination. None of the other aircraft that had used fuel from the same refueling unit reported any problems.

1.13. **Medical and pathological information**

The results of the autopsy and biological and toxicological analyses conducted on the pilot, copilot and swimmer indicated the cause of death in all of them as multiple trauma resulting from the impact. No toxic or hallucinogenic substances were detected in their blood.

The absence of injuries to the pilot's and copilot's hands and feet (control injuries), that is, on the limbs directly in contact with the flight controls (pedals, cyclic and collective), indicated that the impact was unexpected.

1.14. **Fire**

Not applicable.

1.15. **Survival aspects**

1.15.1. *Operation of the distress beacons*

The helicopter had seven distress beacons³²: the aircraft's beacon, one each in the left and right rafts, and the four occupants' personal beacons. Of these, only the aircraft

³² In addition to these emergency beacons, the flight recorder has a pinger that broadcasts on a non-emergency frequency and that aided in locating the aircraft. Locating this pinger required the use of a specific piece of equipment called a hydrophone, which was supplied by the manufacturer.

beacon (HR Smith 503) is designed to activate automatically in certain conditions. The remaining beacons, both on the rafts³³ (Techtest LTD P/N 500-12Y) and worn by the occupants (McMurdo P/N 85-890-001A) are designed to be activated manually.

The emergency signal detection and processing system (COSPAS-SARSAT) received two signals after the crash of helicopter EC-KYR, one from the left raft and one from a personal transmitter, both activated manually by the survivor. The helicopter's emergency beacon did not transmit a signal.

1.15.2. *Inspection of the aircraft's ELT*

The helicopter was equipped with a system from HR Smith (referred to as the aircraft beacon in Section 1.15.1) to relay its position in the event of an accident. When this system detects an impact or flooding condition, it ejects a buoy that contains a battery, an antenna and a transmitter that starts emitting a signal on the emergency frequency. In the accident of EC-KYR, this buoy was ejected but no emergency signal was ever transmitted. The spring charged with ejecting the buoy was stretched out. The system's remaining components were in good condition and were inspected with help from the manufacturer.

An analysis of the components recovered indicates that the buoy ejection was triggered by an acceleration value above the lower design limit and that the ejection process was correct. The elongation in the spring suggests that as the spring was stretching before releasing the buoy, something impacted the buoy, pushing it back and up, probably in the water. This motion of the buoy deformed the spring and could have affected the buoy's integrity.

The buoy containing the battery, transmitter and antenna could not be recovered, which prevented investigators from determining why the emergency signal failed to activate. According to the manufacturer, there is no record of such a problem occurring before.

1.15.3. *Positions of the crew in the helicopter and the survival of the winch operator*

After the completion of the last exercise, the crew's positions were as follows: the captain in the RH seat, the copilot in the LH seat, the swimmer in the back to the left facing forward and the winch operator to the right facing aft. The swimmer was seated and was wearing his safety harness. The winch operator's waist harness was still clipped to the lanyard that was attached to the overhead and that allowed him to move freely

³³ There was a mistake in the information provided by AgustaWestland in its manuals, which stated that the locators in the rafts activate automatically when the raft is deployed. During the investigation this mistake was corroborated with the manufacturer, which confirmed its intention to correct the error in its manuals.

around the passenger cabin. He was on his knees with his back to the captain, putting away the material used in the exercise and talking to the swimmer. During the impact, the doors were thrown outward by the water that rushed into the cabin. The winch operator was likewise ejected, though he remained attached to the helicopter by the lanyard. He took off the harness in the water and climbed on one of the two rafts³⁴ that had inflated as a result of the impact forces.

The winch operator was rescued by a civil guard patrol boat that was in the area after being notified of the accident by emergency services. The operator shot flares, which were seen by the controller at the Almeria tower and by the civil guard. He also lit a flashlight. In addition, he activated the transmitters in the raft and on his vest.

1.15.4. *Helicopter's flotation system*

The flotation system consists of two bladders located at the bottom of the helicopter preventing sinking in case of a ditching. The system is designed for controlled ditching considering the flight manual and sea state limitations, therefore in case of accident impact the functionality is not assured. The impact damage to the structure had broken the pipes that direct gas from the tanks to the bladders.

1.16. Tests and research

1.16.1. *Survivor's statement*

In his statement, the winch operator recalled having finished the exercises and being on the way back to Almeria. He was facing aft, picking up equipment and talking to the swimmer. Everything was normal, he did not notice or hear anything. Suddenly he was in the water and felt a pull downward. He saw that the helicopter was sinking, He removed the waist harness that was attaching him to the helicopter and climbed on one of the rafts. He dove several times to try to rescue his colleagues, but was unable to. He started to feel dizzy (he had a gash in his head) so he climbed on the raft. There, he set off several flares and turned on a flashlight.

1.16.2. *Test flights*

Three test flights were flown, two during the day in Almeria and one at night in Valencia. One was a nighttime training flight with investigators onboard as observers. The goals of these flights were to:

³⁴ The life rafts are deployed by means of a lever in the cockpit or directly in their housings. In this case they were not activated by the crew, but rather as a result of the forces present in the structure during the impact.

- Assess the sensation of climbing-descending that the crew would have felt.
- Assess the crew's workload.
- Assess the time involved in the exercises and the use of the spotlights.
- Assess external references.
- Assess the information of the low altitude in the cockpit.

Sensation of climbing-descending

The flight profile in use on the accident flight was reproduced, such that none of the FD modes were engaged to control the helicopter's stabilization systems. The helicopter climbed and descended several times and, despite knowing what the flight profile was, it was difficult to distinguish between climbing and descending motions. Climbing and descending maneuvers with more sudden transitions were performed. In these cases, the flight profile was much more abrupt and not as smooth, and the changes between climbing and descending motions were easier to feel. These changes demonstrated that the helicopter's stabilization systems and the captain's actions to arrest the ascent resulted in the other occupants' failure to notice the change in the flight path.

Crew workload

During the training flight, observers noted the constant need to coordinate and communicate and to manage cockpit resources, to coordinate and communicate with the winch operator, and said operator's need to do the same with the swimmer. Also noted was the airmanship exhibited during the maneuvers, the constant monitoring of instruments, the reading of checklists and their relevant call outs and the exhaustive planning in the briefing. The workload and the requirements demanded by this type of operation are very high. Also noted was the importance after a maneuver of debriefs to improve team building and management skills and to highlight potential areas of improvement.

Time and use of spotlights on vessel

During winch operations, the vessel is lit and monitored at all times by the pilot's search light. This phase of the operation requires the pilot to turn to the right and look at the vessel or at whatever object he is illuminating with his spotlight. Once the winch operations finish, the spotlight is turned off and the environment transforms from one in which there is one source of light to one absorbed in complete darkness.

External references

At the moment of impact the helicopter was on the runway heading but offset to the right. In that position at an altitude of 950 ft, a runway approach scenario was

considered in which the captain could have thought that he was on the runway heading and decided to descend in preparation for landing. The external references were completely different from those present when approaching the runway, however, with the Cabo de Gata lighthouse clearly visible on the horizon to the right, a small, unlit longitudinal expanse corresponding to the natural park and the lights on the coast from the town of Retamar. The approach to runway 08, on the other hand, is completely illuminated by the city lights. Moreover, the captain was from Almeria and had a house in Retamar, so he knew the area and had been stationed at that base for more than six months, so it seems unlikely that he would have confused two such different settings.

The external references on the path taken by the aircraft made significant changes in bank angle noticeable, but the distance to the coast and the altitude made it impossible to discern changes in altitude using only external visual references.

Low altitude information in the cockpit

The test flight in Valencia was used along with the manufacturer's reproduction of the last two minutes of information displayed on the PFD and MFD. When descending, the first notification is the use of a brown color on the baro-altimeter strip (figure 5). The radio-altimeter is the next display that turns brown, though at high descent rates, the scale of the instrument means that the strips turns brown too late and too fast. The black rectangles associated with the DH are visible thanks to the position in which they are shown on the artificial horizon. The decision altitudes selected and the descent rate made the rectangles appear six seconds before impact.

1.16.3. *Use of taxi lights*

Investigators visited the Almeria control tower and spoke with two controllers to determine how often pilots request, or the tower offers, to land with taxi lights. This subject was raised since, given the location of the base and of the parking stands with respect to the runway, aircraft do not need to taxi the length of the runway and can taxi on the taxiway.

1.16.4. *Helicopter-base communications*

In addition to flight crews, the bases also employ a maintenance technician who, as soon as the helicopter arrives at the stand and with the rotors still turning, and before the crew leaves the aircraft, applies fresh water to specific parts of the helicopter to avoid problems with corrosion. To ensure the technician's presence upon arrival, he is contacted by cell phone, usually by the winch operator, to inform him of the arrival time, especially on real missions when the duration of the flight is unknown. In the case

of training flights, the arrival time is known beforehand and it is not normally necessary to place a call. On the accident flight, the maintenance technician did not report receiving a call and, if he had, it would not have been placed by the captain. No communications were heard on the cockpit voice recorder indicative of such a call, meaning that any distraction in this regard can be ruled out.

This practice was not described by the operator in its manuals.

1.17. Organizational and management information

1.17.1. Oversight of SAR operations in Spain

Regulations specific to SAR activities do not exist in Spain³⁵, where they are regarded as aerial work-emergency operations. The requirements applicable to companies that wish to perform this activity are defined in an internal AESA procedure³⁶. As regards the operation, the requirements are a maintenance manual, an operations manual and a director of operations. In the case of aircraft EC-KYR, the operator, INAER HELICÓPTEROS OFF-SHORE, was authorized by AESA to conduct aerial work-emergency operations, although the basic operations manual was under the name of HELICSA. Once a company receives authorization, the applicable regulation is that for aerial work, namely, operating circular 16-B on flight times, JAR-FCL on licensing and the Air Traffic Regulation.

As for SASEMAR, the following operational requirements were included as part of the technical stipulations in its maritime rescue contract (adjudicated to INAER HELICÓPTEROS OFF-SHORE):

- 50% of flight hours must be devoted to crew training. As a rough guide, eight exercises a month were being conducted per base³⁷.
- Flight crew requirements:
 - Valid commercial license, IFR and/or nighttime VFR.
 - Minimum experience of 2,000 h for captains and 1,000 h for copilots.
 - Type rating on the helicopter being operated.
 - Experience desired in maritime patrols, tracking, aerial surveillance, etc.

³⁵ Article 1 of EC Regulation 216/2008, modified by regulation 1108/2009, which establishes the personnel, operations and products required to maintain a high and uniform level of safety in civil aviation in Europe, explicitly excludes those products, parts, personnel and organizations engaged in search and rescue services. This article specifies that "Member States shall undertake to ensure that such services have due regard as far as practicable to the objectives of this regulation".

³⁶ Procedure for obtaining permits to conduct aerial work (airplanes or helicopters).

³⁷ Eight monthly exercises represent an average of between 16 and 20 training hours (2 to 2:30 hours per exercise). By comparison, in the United Kingdom the number of training hours is 55:15 per base, and real missions do not subtract from this total.

- All of the pilots in the service shall take part in an emergency flight in a flight simulator every 12 months, and within three months of starting their contract. They shall also take part in an exercise to evacuate from an overturned underwater helicopter in the “Dunker” simulator every 12 months.
- Training plan for pilots and mechanics.
- For the maintenance of aircraft, certification as an EASA PART-145 maintenance center.

Oversight of SAR operations in other countries

At the European level, the SAR service in most countries is provided by the military. In the United Kingdom, the service is a joint military-civil operation, with civilian companies providing SAR services. Ireland, Norway and Netherlands also have civilian operators.

Not every country in Europe has developed specific SAR regulations. The United Kingdom is one example of a country that has developed regulations specific to this activity and in May 2010, the United Kingdom’s Civil Aviation Authority (CAA) issued document CAP 999 Helicopter Search and Rescue in the UK, listing the requirements for conducting helicopter SAR activities. These requirements equate SAR activities with commercial transport operations and are based on JAR-OPS 3 (Operation of Commercial Air Transport) and require a SAR Air Operator’s Certificate (AOC).

Chile’s civil aviation authority requires SAR pilots to receive training in CRM (crew resource management) and CFIT (controlled flight into terrain) as part of its ALAR (Approach and Landing Accident Regulation) program. This training is provided by the operator.

1.17.2. Operator’s documentation: BOM and SAR SOM

The operator had a Basic Operations Manual (BOM) and a SAR Special Operations Manual (SAR SOM).

The BOM, dated 12 April 1999, is one of the documents required to obtain a permit as an aerial work company. Since it is a generic manual for all the types of aerial work the company is authorized to perform, it did not contain requirements and details specific to SAR operations, which were covered under the SAR SOM. The name of the company in the BOM was HELICSA.

The SAR SOM, which does not require the approval or authorization of the civil aviation authority, includes all aspects related to SAR activities, including the normal checklists, search and rescue operational procedures and training requirements. It has eight chapters and three appendices, A, B and C.

During the investigation, the following versions and parts of the SAR SOM were obtained:

1. The SAR SOM (copy number 19) of the Almeria base. It was the document used by the accident crew.
 - Revision dated 10-01-2008.
 - All of the pages in the manual were dated 15-02-2007, except for the list of effective pages, some pages in the table of contents and some in Chapters 5 and 6, which were dated 05-12-2008.
 - The list of effective pages for Chapter 6 did not match those in the text.
 - The name of the company listed in the manual is HELICSA.
 - Chapters 2 and 5 and Appendices A and B contained procedures specific to the helicopter models used by the company, but none for the AW139:
 - The emergency procedures were in Section 2.6, *Operating definitions and regulations*. There were no procedures for the AW139.
 - There were no recovery procedures specific to the AW139 (Chapter 5).
 - There was no configuration of onboard SAR material for the AW139 (Appendix A).
 - There were no sea approach checklists for the AW139 (Appendix B).
 - For the helicopter models included:
 - Appendix B contains a sea approach checklist. This list is identified in the text (Chapter 5) as SEA APPROACH.
 - The checklist for climbing following a winch operation is not included as a list, but is described within the text.
 - The text in Chapter 5 refers to an AFTER TAKEOFF list that does not appear in the document.
2. The SAR SOM sent by INAER HELICÓPTEROS OFF-SHORE to the CIAIAC after the accident:
 - Revision dated 05-12-2008.
 - All of the pages in the text were dated 15-02-2007, except for some in the table of contents and some in Chapters 5 and 6, which were dated 05-12-2008.
 - The name of the company listed in the manual is INAER.
 - As in the Almeria copy, the manual did not have procedures specific to the AW139 (Chapters 2, 5, Appendices A and B).
3. The SAR SOM (copy number 5) sent by SASEMAR to the CIAIAC after the accident.
 - Revision dated 10-01-2008.
 - The table of contents does not include Appendices B and C, and they are not in the text.

- All of the pages in the text are dated 15-02-2007.
 - The name of the company listed in the manual is HELICSA.
 - Chapter 4 is missing and there is a Section 5.5 that does not appear in the table of contents.
 - In Chapter 5, there is a Section 5.5.7 on the personal ELT that is not present in the Almeria base copy (with the same revision date) nor in the copy sent by INAER.
 - Chapter 6, Section 6.4 on minimum exercises required to maintain the SAR certification, is not the same as in the Almeria SAR SOM or in the one sent by the company. The SASEMAR version includes training exercises that were deleted in the 05-12-2008 version.
4. AW139 SAR procedures sent by INAER to the CIAIAC after the accident. This document appears to be an update of the SAR SOM chapters relevant to the AW139 and which were not included in the SAR SOM versions.
- The name of the company shown in the manual is INAER.
 - The document is titled AW139 SAR Procedures and it contains Chapters 5, 9 and Appendix B.
 - The document's pages are dated 10-11-2009 and they belong to the SAR SOM.
 - Chapter 5 is from the SAR SOM and contains a new section with procedures for the AW139.
 - Chapter 9, Emergency procedures, is new and does not exist in any of the SAR SOM copies. This Chapter 9, which in the SAR SOMs was included in Section 2.6, contains emergency procedures for the AW139 as well as new sections.
 - There are references to SAR SOM supplements that do not exist in the SAR SOM copies provided.
 - At the end of Chapter 9 there are emergency checklists in English. These lists have the registration and serial number of helicopter EC-KYR and are dated November 2009.
 - Appendix A, which should include the configuration of the SAR materials onboard AW139, is not in the document.
 - Appendix B includes three checklists for approaching vessels: SEA APPROACH, BEFORE DEPARTURE and AFTER HOVER SEA/MISSED APPROACH (Vy).
5. The normal checklist used by the crew at the time of the accident was recovered from the helicopter wreckage.
- There were 12 laminated pages in a folder.
 - Each page was labeled with the helicopter's registration and serial number.
 - The date at the bottom of every page was December 2008.
 - It was in English and contained the following specific SAR checklists: SAR APPROACH and SAR DEPARTURE/GO AROUND.

1.17.3. Operator's documentation: Description of maneuvers in the SAR SOM

Approach to hover

Section 5.3.1 of the SAR SOM, Approach to hover, described the way to conduct a sea approach using a SAR pattern initiated either above the vessel or on long final, with the following reference points, altitudes and speeds. This procedure entails the performance of the "Sea Approach" checklist.

Hover

The hover is described in Section 5.3.3, Recovery of survivors from a vessel, which specifies setting the DH at the minimum hovering altitude planned (e.g. 60 ft). This disagrees with figure 8, which lists a minimum hovering altitude of 100 ft.

Departure

Section 5.3.10, After recovery, of the SAR SOM describes the departure to be performed when the winch operator gives the pilot the "cabin clear" indication. Before starting the return, the copilot must log the time and check the navigation equipment. The departure will adhere to the procedure for departing in instrument meteorological conditions (IMC) and will not rely on external references.

The procedure to be used in all winch operations above a vessel is to level the wings and nose (artificial horizon), apply power as needed, verify positive rate (three climb indications, BARALT-RADIOALT-VSI³⁶, increase speed (10/15° nose down) and continue with standard departure (Vtoss, Vy, selected altitude)).

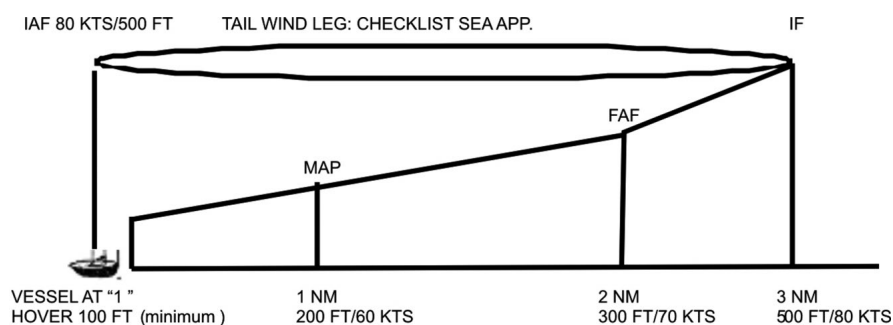


Figure 8. Approach to hover (Almeria base SAR SOM)

³⁶ Baro-altimeter, radio-altimeter and vertical speed indicator. These are the "three greens", or "3 UP".

During the departure the PNF (pilot not flying) will check the power applied by the PF (pilot flying) and say it, the positive climb rate and say it, the pitch angle and will say "gaining altitude/speed", passing through V_{toss} , V_y and 100 ft, 200 ft and final altitude and speed. He will also perform the AFTER TAKEOFF checklist (which is not in the manual).

When taking off in automatic, the parameters must be monitored and at the end of the climb (at 199 ft), continue as in normal flight, setting the radio-altimeter once again to 200 feet or higher.

1.17.4. *Operator's documentation: Checklists*

Prior to the accident there were a total of four AW139 checklists, two of them specific to EC-KYR:

- December 2008. Specific to EC-KYR. This was the list used by the crew at the time of the accident and found with the wreckage.
- July 2009. Specific to EC-KYR. Sent by the operator to the CIAIAC. This list is exactly the same as that dated December 2008.
- November 2009. Generic and part of the document AW139 SAR Procedures sent to the operator to the CIAIAC (described in Section 1.17.2).
- January 2010. Sent by the operator to the CIAIAC.
- July 2010. Sent by the operator to the CIAIAC. Post-accident.

As concerns the December 2008 and July 2009 checklists, the characteristics of the lists specific to SAR operations are as follows:

- There are two, labeled SAR APPROACH and SAR DEPARTURE/GO AROUND.
- These procedures are for helicopters without SAR modes (referred to by the operator as LIMSAR). They do not consider the use of any SAR mode during any phase of the approach or departure; in other words, they do not take into account the technical capabilities of helicopter EC-KYR.
- The SAR APPROACH checklist:
 - Is referred to as SEA APPROACH in the SAR SOM, vessel approach and recovery procedure list.
 - Starts by flying over the target or vessel to start the downwind leg or, if the helicopter is on final, 5 NM away from the vessel on long final. It ends when the cabin door is opened to start winch operations.
 - It has 21 items to check.
 - In all versions, the SAR SOM specifies that the pilot is to perform the sea approach checklist after turning into the downwind leg or prior to 5 NM if on long final. This is incompatible with the phases included in the list.

- The procedure includes checks along the various phases of the approach. The points referred to in the SAR SOM as IAF, IF, FAF and MAP are not employed using the same terminology in the lists (ON TOP for the IAF, CHECK POINT for the FAF, which in this text is 2 NM away and 3 NM away in the lists, and DECISION POINT for the MAP).
- The decision heights (DH) specified in the list are 40 ft for the pilot flying and 200 ft for the pilot not flying. This is the third item on the list and must be verified by both pilots.
- The list includes the hover. The SAR SOM specifies that to hover, the crew will set the DH at the minimum hovering altitude planned. This value, which varies depending on the dimensions of the target, does not match that in the list, which specifies a preset value of 40 ft, or that in figure 8 of the manual, which sets a minimum value of 100 ft.
- The SAR DEPARTURE list:
 - The SAR SOM does not refer to this list by name anywhere, but rather includes it as an “after recovery” item in the LIMSAR procedures.
 - Contains 18 items.
 - The text in the manual specifies that the takeoff is done without external references and is started once the winch operator reports “cabin clear” and that prior to commencing the return, the copilot must log the time and check the navigation equipment. This is not specified on the list.
 - The sixth item, prior to departing from hover, specifies selecting the FD to STANDBY.
 - After disengaging the FD, the takeoff is done in manual, as was done with the previous takeoff. The SAR SOM lists a series of checks performed by the pilot not flying that do not match those in the list (for example, the “gaining altitude and speed” call out that according to the list must be done by the pilot using the term “3 UP”).
 - The list does not specify a reference value for the DH, though the manual defines a value of 200 ft or higher. The SAR SOM does not use the term DH, but rather radar-altimeter setting.
 - The manual requires performance of the AFTER TAKEOFF list, which does not exist.
 - The list following SAR DEPARTURE would be CLIMB/CRUISE/DESCEND.

The list issued in November 2009 has three SAR procedures, called SEA APPROACH, BEFORE DEPARTURE (HOVER) and AFTER HOVER SEA/MISSED APPROACH.

The January 2010 list has two procedures called SEA APPROACH, divided into three phases, and SEA DEPARTURE/GO AROUND.

The July 2010 list has three procedures called SEA APPROACH, BEFORE DEPARTURE (HOVER) and AFTER HOVER SEA/MISSED APPROACH.

There are discrepancies among them, including the use of different terms and item orders.

1.17.5. *Operator's documentation: hiring and training*

Hiring

In its SAR SOM (Chapters 1, 2 and 6), the operator specifies a minimum crew for SAR operations of a pilot, copilot, winch operator and rescue swimmer. Personnel are hired based on their CV and a technical interview. The company had information on the pilots as regards their license, rating, courses and flight hours.

SAR certification

Any crewmember assigned to the SAR fleet must be SAR certified by the company pursuant to its own criteria, since the regulator has no specific requirements.

The various requirements needed to be SAR certified are described in Sections 2.3.1 and 6.1 of the SAR SOM:

1. Section 2.3.1 of the manual lists the following requirements for SAR certification:
 - Training requirements,
 - a final check with a SAR instructor and
 - performance of a certain number of missions under instruction.
2. Section 6.1, SAR instruction, states that in order to be a SAR crewmember, an individual needs:
 - SAR course³⁹: theory part (24 hours) and practical part (8 flights and 10 hours for captains and 6 flights and 8 hours for copilots). The SAR course provided by the company describes the specific content of each training session's theory and practical parts. Theory training contains several parts, including:
 - Eleven theory sessions on the SAR SOM, the contents of which do not match those of any of the three versions made available to investigators.
 - One theory session on CRM, MCC, briefing and debriefing.
 - One theory session on maritime culture.
 - One theory session on the SAR procedures specific to the four helicopter models, including the AW139.
 - SAR instruction program. The number of missions varies depending on the helicopter, the operation and the student's experience.

³⁹ The training does not include specific training on SAR modes.

The dates of the SAR course are known for the both members of the accident flight crew, which included five hours under instruction for the captain, but there is no record of the SAR check being completed, of the copilot's flights under instruction or of the number of missions under instruction.

SAR training

Once SAR certified, an individual must undergo a minimum amount of SAR training to remain certified. These minimums are defined in tables that specify the type of exercise to be performed in a given time period for each member of a SAR crew. SAR training includes nighttime and daytime flights and actual SAR flights count as training flights.

It is this chapter that was modified and differs between SASEMAR's SAR SOM version and the operator's.

The SAR captain plans the flight based on the training needs of the crewmembers and on the time available. It is the captain who logs the training and the times for every member of the crew. Every training flight includes an obligatory briefing and debriefing. The SAR manager monitors the amount of training received by SAR crews. There are no additional references regarding how the training is evaluated.

Lastly, as for the conditions required for training flights, a nighttime flight over water is regarded as a flight in instrument meteorological conditions (IMC), weather minimums are specified as a 400-foot cloud ceiling and a visibility of 2 NM, and a safety vessel shall be present when practicing the recovery of individuals from the water.

The accident flight was a SAR training flight⁴⁰.

The meetings and interviews with the operator revealed that there is no CRM training, nor is it required, and that MCC training covers the use of procedures and crosschecks.

1.17.6. *Safety monitoring*

While some of the companies in the INAER group, of which the operator INAER HELICÓPTEROS OFF-SHORE is a part, do have safety management systems (SMS) and risk assessment programs, such a program does not exist for SAR operations now nor did it exist at the time of the accident. As a result, the risks involved in SAR operations have not been formally identified or assessed based on their degree of severity or frequency. Consequently, there is no way to know which of these risks need to be

⁴⁰ A SAR training flight is not only rescue maneuvers, but starts with the briefing and ends with the debriefing, including flight and SAR maneuvers.

mitigated, avoided or managed as the case may be. This deficiency also reduces the likelihood that the experience gained every day by crews will be adequately used to improve training⁴¹.

There is a means for crews to anonymously report incidents or problems that arise in a flight or that are discussed in debriefs. The INAER group publishes the magazine Safety+.

1.17.7. *Changes in SAR service prior to the accident*

Three years before the accident, the organization of SAR services in Spain had undergone a change. The number of bases was increased from five to eleven, crews spent physically present only in the range of daylight to H24 physical presence and also introduced a new model of helicopter, the AW139 which was a new model and recently certified by EASA.

The operator had to completely reorganize the service: multiply by four the staff, training the pilots and start operating with a new helicopter. The management of all these new infrastructures involved a change and a transition to the new service.

⁴¹ Although the implementation of a SMS (Safety Management System) is not required for helicopter operations, the CAA's Safety Regulation Group recommends it, as well as the requirement to implement a risk management program as part of the Occupational Risk Prevention Program.

2. ANALYSIS

2.1. Flight related aspects

During aircraft EC-KYR's two-hour-and-sixteen-minute operation, the crew made five approaches to hovers, hovers and departures, of which all five approaches, two hovers and three departures were done in manual. The copilot was the pilot flying during the first hour of flight and all of his maneuvers (three approaches, two hovers without winch operations and two departures) were in manual. The captain was the pilot flying during the last hour of flight and all of his approaches were in manual. The hovers he did in FD modes, since they involved winch operations, and of the takeoffs, he did two in SAR Transition Up mode and the last one in manual.

The change in control was clear in every case and expressed with the words "I/You have the controls".

2.1.1. *Analysis of approaches to hover*

The speeds, distances and altitudes used in the approach to hover maneuvers did not conform to the values specified in the SAR SOM or in the checklists used by the crew. The speeds were higher, the altitudes lower and the distances shorter at the start of the descent. In the first two circuits, they flew over the vessel at 500 ft, on the third approach this point was simulated in the vicinity of the vessel at 500 ft and in the last two the circuit was linked to the takeoff maneuver at 200 and 300 ft. The flight paths on the first four approaches conformed to the standard rectangular shape and on the last, all of the corners were rounded off resulting in an elliptical trajectory.

The SAR APPROACH checklist used by the crew was not performed in the same way on every approach. Except for the third approach, the order in which the items on the SAR APPROACH checklist were completed did not match the order in which they appear, and the number of items checked varied:

- On the first approach, 60% of the list was completed, with items out of order and items mixed from different phases of the approach.
- On the second approach, 20% of the items were completed but out of order.
- On the third approach 85% was completed, with the first fourteen points in order.
- On the fourth approach 60% was completed, with items out of order and mixing items from different phases of the approach.
- On the fifth approach 9% was completed but out of order.

This indicates that the list was not used on any of the approaches, except for the third, either when executing the approach or for verification afterward in the event that it been performed from memory. The checks that were made were from memory and

followed no single pattern. On the third approach, during which 15 items were checked in the prescribed order, the crew did not finish the list. The captain's reminder at one point to the copilot to make sure to do the SEA APPROACH or not to forget "the 102" or the question to confirm if he had finished it indicate that it was not standard practice to perform the lists, which were executed from memory.

Items 1, 10 and 15 on the SAR APPROACH list involving a check of the speeds, altitudes and distances at various points on the approach were not completed since the circuits were flown using values different from those specified.

The decision height, DH, which is item 3 on the list and which must be set at 40 and 200 ft, is further proof that the lists were not used. At no point in the flight were the proper DHs set for the pilot and copilot, as shown in table 3. The references to DH throughout the flight suggest that the crew did not place much importance on it as a safety element and that there was a certain confusion regarding its usefulness. The term DH was used to talk about the baro-altimeter or to indicate that the maneuvers would be carried out in manual.

Time	Exercise	DH (ft)	DH (ft)
		Copilot (List requires 40 ft)	Captain (List requires 200 ft)
18:02		0	200
18:29	1st	190	200
18:30		120	120
19:18	2nd	120	40
19:22		120	40
19:48	3rd	70	40

Table 3. Decision heights (DH) set during the flight

2.1.2. Analysis of SAR maneuvers

The hovers and winch operations complied with the guidelines in the SAR SOM: coordination among all crewmembers to check frequencies, acknowledgment of instructions between the winch operator and the pilot flying, monitoring of power and fuel for the maneuver, transfers of control, the loss of the captain's visual references during winch maneuvers and the clear identification of the start and finish of the maneuvers.

Properly speaking, the winch operations comprise the rescue maneuvers and are the ultimate goal of the operation. On the accident flight, the difference between what might be considered as "flight" maneuvers and "rescue" maneuvers were clearly understood.

This difference in terms of the importance of the latter with respect to the former was reflected in the strict application of and compliance with procedures.

2.1.3. *Analysis of departures*

Of the five departures, three were done in manual, as specified in the SAR DEPARTURE list. In every case the pilot flying reported his intention to start the departure with terms such as "we're leaving" or "let's get out of here", but he did not request the SAR DEPARTURE checklist, nor was the start of the performance of the list identified.

In the first two departures, 17% of the list was checked and in an order different from that written. During the third departure, none of the items was completed and in the last two departures, 11% of the list was done. The use of terms such as "three green" and "applying power", which do not match those indicated on the list, suggests that the list was executed from memory all five times and that it was not used to double check the actions taken.

The departure list differentiated between the checks to be made before taking off, during the takeoff itself, and included six memory items and other subsequent checks. The preliminary checks were not fully executed and the subsequent checks were not done at all. After the hovers involving winch operations, the start of the departure took place after the winch operator reported the door being closed and latched. This confirmation must also be given by the pilot not flying and is the first item on the list.

In contrast to the winch operations, during which every crewmember was focused on the maneuver, the departures were used to discuss problems with previous maneuvers and for other aspects of the flight, such as communicating with the vessels. On the last departure, the takeoff was started and the FD disengaged before the door was reported closed and latched, and the copilot, once notified of the takeoff, immediately started talking on the radio with the Salvamar. This precipitation is indicative of a desire to make the most of the flight and to prepare for the next exercise. It is also another symptom of prioritizing SAR maneuvers at the expense of other phases of flight that are made equally critical by the proximity of the water.

2.1.4. *Analysis of climbs, transits and descents*

There was a checklist for climbs, level flight and descents (CLIMB/CRUISE/DESCEND list). On the accident flight, this list was not used during any phase of flight nor was it mentioned. The cruise altitudes for transitioning between exercises were set by the captain at 500 ft, with the exception of the last climb, on which he did not communicate his intention.

In conclusion, and regardless of how the checklists were designed (Section 2.4), the analysis of the maneuvers and the execution of the checklists during the flight reveal a priority and focus during the operation on the "SAR mission, on the rescue" exclusively, meaning the winch operations, with the rest of the flight receiving a lower priority. This mindset is easy to understand considering the activity involved in a SAR flight, where the response time to arrive at the site and initiate the rescue is crucial and can mean the difference between life and death. This culture of urgency was so rooted that the sense of urgency to arrive at the ship and commence winch operations even permeated the training flights. That is why the transits, the checks and the lists were ignored. Several safety recommendations are issued for the operator and intended to instill the importance of all phases of flight, not just "the mission or the rescue itself", to train on the thorough completion of checklists and on the sterile cockpit concept so as to avoid communications that are unrelated to the flight, such as with support vessels, for example, during critical phases of flight.

2.1.5. *Analysis of last departure and descent until impact*

Helicopter EC-KYR impacted the water in a controlled manner and inadvertently. The inputs to the collective and cyclic FTR and the response to the master caution light (MCL) indicate that the captain was providing deliberate and conscious inputs to the controls until the moment of impact and ruled out inadvertent inputs to the controls. The absence of "control" injuries to the pilots suggests an unexpected impact. The final inputs to the collective and cyclic controls seconds before impact are not consistent with those of an evasive maneuver made by a crew that is aware of the imminent impact. These inputs were not sudden (referred to colloquially as "yanking" on the stick). Lastly, the absence of comments by either pilot prior to the impact further show that the impact was unexpected by the crew.

The sole purpose of lowering torque from 83% to 30% at the moment of impact with the collective was to descend and lose altitude, and indicates that the captain misjudged their actual altitude.

The instruments were displaying information correctly, as was verified by readings from other phases of the flight. The possibility that an instrument error could have given erroneous information to the crew can thus be ruled out. Likewise, the engine response was consistent with the crew's actions in the cockpit until the moment of impact, meaning an engine problem can also be dismissed as the cause of the crash.

The constant course used on the return flight is not what would have been expected, since the crew should have initiated a turn after reaching the safety height. The course taken also rules out the possibility that they were proceeding to the Almeria VOR.

In terms of the captain's decision to climb to 950 ft and subsequently descend, the reason for doing this could not be ascertained, although the inputs to the collective FTR

and the gradual transition indicate that these actions were taken deliberately by the captain to, at least, arrest the climb. Since the transits during the flight, even the longer ones, were made at 500 ft, the possibility exists that the captain wanted to descend to 500 ft and start the approach from there. This option could not be confirmed since in the conversations recorded in the cockpit, the captain makes no mention regarding the altitude he wanted to attain after the departure. At any rate, whether the goal was to transit at 1,000 ft or 500, the action to lower the collective to decrease power and altitude, and which was made throughout the descent until the moment of impact, resulted from the captain's belief that their altitude was higher than it actually was.

The crew's external references during the climb and descent under artificial light were different from those of the airport. The captain was from the area, spent his summers there and had flown in the area sufficiently long to have been familiar with the area. Moreover, the request for the BEFORE LANDING checklist, which is done before the approach, rules out the possibility that the captain was confused and thought they were landing. The landing approach speeds are completely different from that at which the aircraft was flying, and the trend was not one of decreasing speed for landing, but exactly the opposite.

Perception errors from the use of spotlights and from accelerations have been ruled out. The use of spotlights on moving surfaces, such as fields with tall wheat or the ocean surface, can result in a false sense of altitude, but such an effect would have occurred during the hovering maneuver and not two minutes later. A physiological process in the ear associated with acceleration can result in a feeling of climbing, but in this case, a considerable amount of time had elapsed since the climb, meaning that such a phenomenon, had it occurred, would have manifested itself much earlier.

The transition between the climb and the descent and the helicopter's stability indicate that none of the helicopter's other occupants noticed the descent and the change between the climb and descent. This coincides with the statement made by the survivor.

With regard to the instrument check, the references to "three greens" and the change to the QNH pressure for the landing in Almeria indicate that the captain was checking the instruments during the climb. From that moment on, investigators were unable to determine whether he used external references or instruments, since there are no additional checks of any flight parameters. A minute before impact, he checked the time, but it could not be determined whether he did so using his wrist watch or the helicopter's chronometer.

As for the copilot, at the start of the climb he seemed not to know what the captain was doing, saying "your heading is set", with the captain replying "I don't have anything. One, two, three". The copilot then immediately started talking to the vessel. From that moment on, he focused on the radio transmissions that would occupy him for almost the remainder of the flight. Once, while climbing, the copilot is clearly heard

picking up the lists, finding the BEFORE LANDING list and reading the first item. He did not monitor any of the flight instruments.

The LANDING GEAR and ONE FIFTY FEET warnings that appeared in the last six seconds before impact were acknowledged by the captain because he turned off the visual warning light, meaning he heard them. These warnings had no effect, however, in the sense that he was unaware of their altitude and descent rate (1,600 feet/minute). His inputs to the controls were not as drastic as they needed to be.

A repeated exposure to a stimulus of any kind decreases the response time, leading to a habituation effect⁴². In this case, the LANDING GEAR and ONE FIFTY FEET acoustic warnings failed to alert the crew to their situation due to the habituation effect, since it was the 12th time they sounded during the flight. While the captain did reduce the descent rate from 1,600 ft/minute to 250 ft/minute, this seems to be a learned or conditioned response, given the number of times this warning had sounded previously, and not a reaction to an imminent impact.

The captain's action to acknowledge the time one minute before impact, interpret what he was seeing on the clock, remember the approach category and determine, given their estimated time of arrival, whether they would be able to refuel, rule out a complete loss of situational awareness on the part of the captain. The above does not indicate what the captain's intentions were, but he was clearly not planning to land; rather, there are signs that he had misjudged their altitude.

Causes of the misperception of height

The actions to lose altitude despite already being descending were due to the captain's misperception of their altitude; in this case, he thought them to be at a higher altitude than they actually were. The causes of this misperception were:

- a visual illusion stemming from the use of external references, or
- a misinterpretation of the information provided by the flight instruments, or
- a combination of both.

The sole and exclusive use of external references when flying over a featureless terrain such as water, and at night, is a clear example of an ambiguous stimulus that can lead to a misperception. The external references available to the crew allowed them to discern the horizon and changes in bank angle, but not to ascertain their altitude, and much less to notice an inadvertent drop in altitude. In other words, if they only used external references, it is highly likely that they misperceived their altitude. Had this been the case, the captain would have been "looking outside" and not at the instruments in

⁴² Habituation to a stimulus of any type diminishes the response time as the sensory threshold rises. A noisy room, for example, stops being noisy over time due to this habituation effect.

the last minute of the flight, an excessive amount of time for a pilot with his experience. As for the copilot, in the last phase of the flight he was doing the BEFORE LANDING list and had read the first item, which indicates that he had picked it up and was doing it, after which he started talking on the radio with the control tower.

The second possible cause of the misinterpretation of the instruments could have occurred had the crew not crosschecked the instrument readings, or if they partially did, due to adjusting the information displayed to fit their own expectations at the time, thus interpreting the altitude to be what they thought it was instead of that actually displayed by the instruments. The captain knew the area and had experience flying there. His mental picture of the situation would thus have included an expected altitude value. Moreover, the descent rate caused that the information about the proximity to the ground (the brown color on the displays) appeared very late and closed to the impact.

The information available on the accident could not confirm either of the two causes or a combination of the two.

The condition in which the crew began the final two minutes of the flight is analyzed in Section 2.2.2, and considers the fatigue resulting from the excessive workload involved in the flight. Also considered is the possible influence on the events of those final two minutes of:

- Changing light conditions: the captain had been looking at an intense and localized light for ten minutes, a light that was turned off at the conclusion of the exercise, plunging the crew into the darkness of the night and cockpit. This change could have caused him to reduce his vigilance.
- Changing workload: the crew went from a very demanding task to one that was more mundane and less demanding (the return flight), which could have resulted in a decreased attention span.

A person affected by these three factors, fatigue, less light and a less demanding task, is more likely to become less alert, which in turn increases the likelihood of succumbing to errors in perception.

2.2. Aspects involving the crew

2.2.1. *Qualitative analysis of cockpit communications*

The captain's use of the crew members' names and expressions such as "do you agree?" resulted in a mood of harmony, cordiality and mutual respect in the cockpit. The captain and the copilot were clearly motivated to obtain the maximum training benefit from the flight – the first exercise was repeated and the lights on the Salvamar were turned off to make the exercise more realistic.

The roles assumed by the crew on the flight were those of instructor and student, more than those of captain and copilot. Both the captain and the winch operator wanted to help the copilot learn. The copilot's constant questions to the captain and the captain saying "let's review some basics, ok?" indicate the copilot's clear desire to learn and the captain's desire to teach. The captain, who had been an instructor previously, tried to teach him using training tricks such as modeling, telling him how he would do the maneuver. This relies on using indirect language to indicate how to proceed without giving an explicit instruction.

The copilot's flying skills during his maneuvers as the pilot flying were not optimal, as evidenced by the captain's reminder on the first departure "don't overshoot it, you don't have three greens yet". Choosing the wrong wind direction on the first exercise and hovering in manual made things more difficult. The copilot's constant justifications and explanations after each maneuver could be indicative of a feeling of frustration and insecurity. When the captain was the pilot not flying, he was constantly monitoring the copilot's actions and giving him instructions. This resulted in a high workload for the captain and in certain frustration in the copilot who, in his desire to learn, only became more self-conscious of his limitations.

During the maneuvers in which the captain was the pilot flying, he performed tasks done by the copilot, anticipating his actions. The copilot's indirect communications to the captain such as "I'll do it if you want" are quite common in copilots and symptomatic of the cockpit hierarchy effect⁴³. This gives an idea of the captain's authority over the copilot, since in these situations it is the captain who has the knowledge, and this serves to undermine the copilot's own judgment.

The use of phrases by the captain such as "you're the boss", followed by the contradictory action of doing tasks himself that should have been performed by the copilot, and on many occasions without even reporting them, result from not being able to achieve two contradictory wishes: that of giving more autonomy and confidence to the copilot on the one hand, and to control every aspect of the flight as a result of not sufficiently trusting the copilot's skills and knowledge on the other⁴⁴. This situation, with the captain taking on his own duties and many of the copilot's, required him to use more cognitive resources than would normally be necessary on a training flight.

The copilot lost situational awareness on three occasions, 15, 10 and 2 minutes before the impact. The copilot expressed his confusion to the captain ("I didn't know what you were doing, I was a little...", and "I don't know where you changed... but we are on downwind, the wind is from the right..."), but he was not assertive enough, perhaps because he doubted his own judgment in light of the captain's expertise or because he

⁴³ Ute Fischer y Judith Orasanu. Georgia Institute of Technology: NASA Ames Research Center.

⁴⁴ Instructors and expert pilots who have flown with inexperienced pilots know that this contradiction is not easy to resolve, especially if, as in this case, there is a desire to help. CRM training includes conflict management and provides guidance on dealing with this type of situation.

wanted to maintain that feeling of cordiality he had with the captain before and during the flight. This situation could have led to frustration, especially in a person who is motivated and wants to learn. However, the copilot made an effort and managed to be on the loop again. On the last departure, the copilot had problems keeping up with the captain's actions ("your heading is set", "I don't have anything. One, two, three"), and thus decided to focus on the radio communications.

The captain also wanted to use the flight to learn and automate actions ("why did I have to think, it's better not to think. These things are automatic, when we think..."). He was aware of the usefulness of automating actions, and stated that he had not automated them due to a lack of training. There was a noticeable lack of familiarity with maritime terminology.

When the swimmer was lifted onboard and the exercise was completed, communications in the cockpit changed. The captain's tone became less active, more subdued, and intentions were not expressed as much.

2.2.2. *Crew fatigue: analysis of errors and workload*

Errors occur frequently, as shown by the LOSA (Line Operations Safety Audit) program. Thus, identifying errors is essential to managing them. Over the course of the flight, 16 errors were made by the captain, of which he identified and managed 10: all of the skills errors⁴⁵, 6 of the 8 rules errors⁴⁶, and 2 of the 6 knowledge errors⁴⁷.

Detecting skills errors requires less attention and cognitive resources than detecting knowledge errors. Table shows that as the errors required greater attention, the captain's ability to detect them decreased. Since attention is directly affected by fatigue⁴⁸, since the more automated a task is the less attention it requires and since the

⁴⁵ Skills-based actions (Rasmussen, 1983) are those that become highly automated through practice. Carrying them out requires little awareness and attention, thus they place low demands on one's cognitive resources. An example of this type of action is flying at a given altitude.

⁴⁶ Rule-based actions (Rasmussen, 1983) are those that are carried out based on rules and require greater conscious control and more cognitive resources than skills-based actions. An example of this type of action is applying a procedure.

⁴⁷ Knowledge-based actions (Rasmussen, 1983) are those that are carried using new rules that build upon what has been learned and memorized. They rely heavily on mental resources, require a high level of attention and are the first to be affected by fatigue. An example of this type of action is handling an emergency or making decisions in unknown situations.

⁴⁸ There are different types of fatigue symptoms: physical (falling asleep, nodding off, rubbing one's eyes, yawning, lack of coordination, headaches), mental (increased number of errors, difficulty making decisions and remaining alert or lapses in work routine, such as selecting one altitude instead of another or confusing one word for another) and behavioral (irritability, anger or lack of motivation).

Fatigue has a greater effect on decision making than on flight skills, since the former requires greater attention and resources than the latter. Fatigued pilots find it more difficult to execute procedures, take longer to reach a conclusion and make more conservative decisions (University of South Australia, Adelaide).

detected errors decreased along the flight, not managing errors of this kind could indicate fatigue. They also required an additional mental effort due to not having yet been automated, possibly because they had not been sufficiently trained on or corrected.

Type of error	Number of errors	Number of error managed
Skill	2	2 (100%)
Rules	8	6 (75%)
Knowledge	6	2 (33%)

Table 4. Number and types of error made by the captain

The last two minutes of the flight, with gradual transitions that were not felt by the other crew members, indicate that the captain retained his flying skills until the impact. Automatic skills are less affected by fatigue since they require less work and attention. Not initiating the turn on the return to Almeria, on the other hand, which is a decision requiring more attention and work, could be symptomatic of mental fatigue, as with the previous descent. The yawn, the inability to finish words and the reduced energy in the captain's voice during the final two minutes of the flight could also have been physical symptoms of fatigue due to the following factors.

Based on the CVR analysis, on the maneuvers during the flight and on the history of the flight, the following factors have been identified as affecting both the captain's and the copilot's workload:

Captain:

- The attention required by the SAR exercises over the course of a two-hour-plus flight.
- Working at night over water at a low altitude, changing from instrument to visual and from light to dark, requiring great concentration.
- High professional demands to maximize training value by completing and repeating exercises, recreating the most realistic lighting conditions and flying most of the mission in manual.
- Task saturation: role of captain, part of copilot's role by taking on some of this tasks and acting as instructor to compensate for the copilot's lack of training.
- Uneven workload in the cockpit: in addition to the mission's demands, there were those resulting from the uneven sharing of tasks in the cockpit and which led the captain to oversee both the winch operations and much of the flight operations, both during those phases in which he was the pilot flying and during those in which he was not.
- Supervision of copilot's actions and communications: the captain delegated actions and decisions to the copilot and encouraged him to make those decisions

corresponding to the copilot while at the same time retaining control, supervising and monitoring, both while acting as the pilot flying and pilot not flying. This was probably because of his inability to resolve the conflict between his desire to maximize the copilot's learning while at the same time not being fully confident in his abilities.

- Crew resource management, which he had not been trained on in this helicopter.
- The lack of training and unfamiliarity with the maritime terminology that required them to devote more attention than would otherwise have been required to both communicate with and give instructions to the vessel.
- Emotional responsibility to help the copilot improve his flying skills without affecting their good relationship.

Copilot:

- The attention required by SAR exercises over the course of a two-hour-plus flight.
- Working at night over water at low altitude with little experience.
- Flying the first part of the mission in manual as pilot flying with a wrong position with respect to the wind which required an additional effort to keep the helicopter at the required position and altitude.
- High demand to make the most of the training flight.
- Lack of training and experience on this helicopter and very low nighttime SAR experience, requiring him to maintain a level of attention that exceeded what would have been required from an expert pilot for this type of flight.
- Unfamiliarity with maritime terminology and having to express it in a language that was not his native tongue.
- Effort to keep up in certain phases of the flight when the captain was doing the copilot's tasks, both while as pilot flying and as pilot not flying.
- Effort to communicate fluently and to understand cockpit messages in Spanish⁴⁹.
- Emotional effort to maintain a good personal and professional relationship with a captain he held in high esteem, who helped him learn and who expected him to be more self-reliant. This emotional aspect could have impeded him from expressing his opinions more openly.

2.2.3. *Crew training and experience*

The captain had ample experience flying helicopters, sufficient experience on the AW139 and little experience in nighttime SAR. The copilot had average experience flying helicopters, little on the AW139 and very little experience in IFR and nighttime SAR.

⁴⁹ Although he spoke fluent Spanish, he had problems with prepositions, with location adverbs when talking about the ship's position ("there, in front near"), with the use of indeterminate articles, with the verbs "to be" (*ser* and *estar*) and the use of the subjunctive and indicative.

The basic training (SAR course) that pilots receive to be a SAR crew member needs to be complemented with constant training in order for the crews to acquire basic flight skills on each helicopter model and to train on the highly complex SAR maneuvers specific to each operation. Training allows for tasks to become automated, meaning the crews experience less fatigue and have more cognitive resources available to face any eventualities associated with an operation.

Although minimums SAR training established by the operator had been fulfilled both the captain and copilot had flown very little in the last three months. The copilot's problems with basic flight skills, the crew's difficulty with the use of maritime terminology and the captain's statement, "I'm landing, ok? I haven't done a landing in ages", are clear indications of a lack of training. An average of 25 hours every three months is considered insufficient to maintain the highly specific skills required in this activity⁵⁰.

The number of training hours is conditioned by the budget assigned by SASEMAR in the maritime rescue contract. As a result, a safety recommendation is issued to SASEMAR to take the necessary measures from a budgetary standpoint to increase the number of training hours for SAR crews.

In addition to the need for greater crew training, it is recommended that the operator, INAER HELICÓPTEROS OFF-SHORE, modify its planning schedule to reduce the duration of exercises and increase the number of training days so as to ensure more continuous crew training.

Another important aspect involves the kind of training given to crews. SAR activities require a high degree of coordination among crew members and clear and efficient task sharing. Such an activity calls for a multi-crew training (CRM and MCC). A safety recommendation is issued to both SASEMAR and the operator to require that SAR crews receive proper multi-crew training.

2.3. Aspects involving the aircraft

The inspections of the fuselage and engines ruled out any problems associated with these components as a factor in the accident. The response of the engines was consistent with the control inputs.

The helicopter impacted at high speed, and the structural damage was consistent with such a high-energy impact. As a result, the flotation system, which keeps the helicopter from sinking and is designed for a planned water landing, did not work.

⁵⁰ In absolute terms, the number of training hours is low. In relative terms, the SAR operator questioned by investigators has more than double the number of training hours per base.

Distress radiobeacon

The aircraft's distress radiobeacon was ejected as a result of the impact, as per its design criteria, but it did not transmit an emergency signal. It was damaged during the impact and did not work properly. Although the helicopter had six additional emergency radiobeacons (one on each crew member and on the two life rafts), the ELT was the only one that should have activated automatically. Its proper operation, thus, is essential from a survival standpoint. In this case, the proximity to the coast, the last radar returns, the beacons activated by the survivor and the flares allowed rescue crews to locate the site quickly. The importance to survival of the proper operation of an ELT after an accident requires that a safety recommendation be issued to the certifier of the equipment, the EASA, in order to review the functional tests that are performed on distress radiobeacons under impact conditions such as those that affected EC-KYR.

Tracking and correcting deferred items

The status of the resolution and tracking of deferred items in aircraft EC-KYR underscores several aspects related to the maintenance of the aircraft.

The deferred items had been logged for two months. Two of the items affected by the MMEL (although is not mandatory it was used by the operator) involved airworthiness: the possibility of being left without lights in the cockpit during flight, and having to fly with one display inoperative. The first should have been fixed on 14 December, but the aircraft continued to fly with the item deferred. The flickering copilot MFD, while not logged using the word "inoperable", in fact resulted in the pilots flying, both on the accident flight and in previous ones, with the display turned off, a situation that was prohibited for nighttime operations. In other words, given the condition of aircraft EC-KYR on the day of the accident, it should have been grounded as per the MMEL. In addition, this deferred item was affected by the flight rotor manual. Assuming that the flickering started during the flight, once it becomes inoperative in flight and it switched off, the copilot should hand the controls to the commander. Therefore according to the flight manual the training mission must have been aborted as the copilot was not allowed to fly the helicopter.

The third deferred item involving the acoustic warning associated with the decision height, DH, highlights two aspects: one, the fact that the deferred item was in fact working indicates that the status of the aircraft was not being tracked; and two, that crews were not reporting the problems they encountered onboard. Moreover, while this acoustic warning does not reference the DH in the specific software version in use, the warning is of particular importance to SAR operations. Such a condition would preclude SAR operations and should be a condition to perform SAR operations. With this objective, a safety recommendation is issued to develop a minimum equipment requirements list specifically for SAR operations.

Lastly, two other recommendations are issued to review the time deferred items are left unresolved and that the items reflect the actual condition of the aircraft.

Use of helicopter aids

The analysis of the accident flight revealed that the technical aids available in the helicopter to prevent an inadvertent loss of altitude were underutilized, specifically as regards the use of the decision height, the SAR modes, the working altitudes that generate nuisance warnings and the FD collective modes:

- Decision height: the crew did not make any comments when this warning, which should have been inoperative, sounded on the first approach. This reaction indicates that they had become accustomed to flying without this aid and that they gave it little importance. At no time during the flight was the DH set as specified in the checklists. The DH is not used in every phase of flight, as indicated by its omission from the SAR DEPARTURE checklist. Lastly, the term DH was used to refer to other concepts such as baro-altitude or FD and SAR modes. This information points to the relative insignificance crews gave to this aid of such vital importance during low-altitude operations.
- SAR modes: the failure to use the SAR modes in the exercises and the preference to do them in manual resulted in the LANDING GEAR and ONE FIFTY FEET acoustic warnings sounding twelve times, and the ensuing habituation effect this produced. Operating in MOT or TDH SAR modes inhibits the LANDING GEAR warning, among other reasons so as not to bother the crews. This warning is thus given when an actual hazardous condition exists and has the desired alerting effect when it sounds.
- Choice of working altitudes: on the accident flight, the working altitude selected during one of the exercises was 150 ft, which resulted in the ONE FIFTY FEET warning sounding eight times in a row. While this warning cannot be inhibited (except using the AWG switch), it would be prudent to avoid such low working altitudes unless strictly necessary so as to avoid the saturation effect and to have the warning retain the desired alerting effect on the crew.
- Collective FD modes (fly-up function): the use of the FD modes that involve control of the collective have a safety function associated with them that automatically prevents the helicopter from descending to terrain. This aid is very important and should be used in any phase of flight whenever possible. When the helicopter is flown in manual, that is, by disengaging the FD from the autopilot, this protection disappears. The list onboard the helicopter included selecting the FD to standby, meaning that this function was rendered inoperative on every departure.

The underutilization of all the features available in the helicopter is indicative of the operational safety culture, as will be analyzed in Section 2.4. A safety recommendation is issued to the operator to ensure that all of the technical features offered by helicopters, and which allow for the safer performance of SAR operations, are utilized.

2.4. Aspects involving the operator

An analysis of the operator's documentation allowed investigators to identify discrepancies, some of them serious, between the content in the various SAR SOM versions in the bases and INAER and SASEMAR offices.

The first discrepancy involves the name of the company shown in the manuals. In some, it is given as HELICSA and in others as INAER, but none of them list it as INAER HELICÓPTEROS OFF-SHORE. These discrepancies indicate a lack of oversight by authorities. There are errors in the page numbering and differences between the table of contents and the text that suggest a lack of quality control in the documentation.

The discrepancies in the contents affect, as shown by the accident, the reality of SAR operations and the conditions in which they were carried out. The purpose of the SAR SOM is to reflect how operations are performed, and it should serve as a reference guide so that all operations abide by the same safety standards. The SAR training is based on the SAR SOM, meaning that this manual must accurately reflect how operations are done.

At the time of the accident there were no SAR procedures for the AW139 helicopter, despite the fact that this helicopter had been in use at the company for years. None of the copies of the SAR SOM reviewed included such procedures. The crew used generic procedures that did not incorporate the technical features available in helicopter EC-KYR.

The problems identified with the structure and contents of the SAR SOM are considered serious in terms of the design, contents and review of the SAR SOM and how it adapts to the reality of SAR operations in general, and of the absence of any mention of the AW139 in specific, and are the object of a safety recommendation.

- The procedures to be used were not easy to find and identify, since there were procedures in Chapters 2 and 5 and Appendices A and B.
- Only the approach to hover procedure was identified. The remaining SAR procedures were not listed.
- The departure procedure was included in the text but not in the form of a list. This indicates the importance that was assigned to this phase of flight.
- The emergency procedures were included in a chapter on definitions and operating regulations.
- The text made references to the names of procedures that did not exist (such as the AFTER TAKE OFF list).
- The manual specified a series of checks by the copilot on takeoff that were not executed in reality and that did not match those included in the checklist.
- The identification of the lists onboard the aircraft did not match, even by name, those in the SAR SOM: SAR APPROACH versus SEA APPROACH.

- The way to perform maneuvers described in the SAR SOM disagreed with the speeds, altitudes and distances given in one of the checklist items.
- The decision heights in different parts of the SAR SOM texts did not agree with each other or with those in the lists.
- The content of the checks and call-outs in the SAR SOM and the checklist do not match.

All of the SAR SOM versions analyzed revealed problems of the same nature as those described, with serious discrepancies in terms of the contents and layout, a lack of specific procedures that did not reflect reality or the technical capabilities of the aircraft, and a lack of uniformity among the procedures, starting with such basic things as their different names.

The checklists obtained from the operator also reveal problems with the control and distribution and with the adaptation of the documentation to the technical capabilities of the aircraft. There were several versions of the same list that did not reflect the same guidelines that were specified in the SAR SOM. Not only was the revision number of the onboard lists two versions earlier than those available at the time of the accident, but the list did not reflect the technical capabilities of aircraft EC-KYR.

Among the most serious findings is the fact that the SAR DEPARTURE list requires disengaging the FD before departure, this being one of the very aids that would have prevented the helicopter's descent to the water.

The design of the SAR lists (SAR APPROACH and SAR DEPARTURE) does not achieve the goal for which checklists are designed, which is to ensure the proper configuration of the aircraft. They do not correspond to specific phases of flight, but rather encompass several phases. The SAR APPROACH list includes 21 unnumbered items and must be interrupted three times. The SAR DEPARTURE list has 18 items, also unnumbered. The amount of time and distance required to do the list precludes its completion without interruptions.

The lists are written and spoken in English, with call-outs in English that do not match those listed in the SAR SOM. They also use different terminology depending on the document used. In fact, the cockpit communications during the accident flight used terms in both Spanish and English (prelanding - *pretoma* – before landing, sea approach – approach to hover) that reveal a lack of uniformity and adaptation of the lists to the reality of operations.

The contents of the SAR ground course did not correspond to the reality of the organization at the time of the accident, as evidenced by the fact that the table of contents of the SAR manual is not the same as that in any of the SAR SOM versions analyzed during the investigation. Also, although the course contains a study of SAR

procedures for the AW139, these procedures were not implemented. The training programs also make no mention of training geared specifically to the SAR modes.

SAR SOM Sections 2.3.1 and 6.1 on training specify somewhat confusing criteria on the training required to be a SAR crew member, with flights under instruction being required in some cases and not in others. For example, the captain had documented flights under instruction, whereas the copilot did not.

After the SAR course, no further refresher courses were given, nor were each crew member's SAR skills or operations as a whole evaluated. As a result, learning took place as part of their daily job and not as part of training. The training flights are not supervised or evaluated by anyone outside of the debriefings held by the crew. On the accident flight, the crew did part of the debriefings at times when they should have been performing checklists.

This situation does not allow the operator to ascertain the skill level of its crews or the level of safety of their operations. It is the crews themselves who see to it that these training and supervisory needs are met during the flights. Training flights should provide training for every crew member. To make these flights more effective, the crews should be evaluated by a non-crew member. The debriefings held by the crews are very useful in this regard, but require specific techniques and skills that have to be learned. The crews, given their involvement in the operation, are generally not ideally suited to evaluate themselves. As a result, a safety recommendation is issued to ensure that training flights are more effective and provide training to all crew members.

The training provided to and required of pilots for SAR operations is that of a single-pilot type rating. And even though the helicopter is certified for a single pilot, a SAR operation is a multi-crew operation. In fact, the aircraft's flight manual defines a minimum crew of two pilots for SAR flights. The operation requires constant coordination, supervision and a clear allocation of tasks for all crew members. A safety recommendation is thus issued regarding the multi-crew training for SAR operations.

Crews are prone to take risks for the sake of the rescue. The risks involved in the operation should thus be determined so that they can be identified and managed. Due to the nature of SAR operations, a safety recommendation is issued so that a safety management system (SMS) is implemented for SAR operations.

2.5. Aspects involving the regulator

There are no specific regulations in Spain for SAR operations, which are regarded as another aerial work. Safety recommendations are issued to the regulator to draft regulations specific to the special characteristics of SAR operations, as has been done in other countries. These regulations should consider the need for a multi-crew training to

engage in SAR operations, requirements for language skills and the need for SAR service providers to implement a SMS. They should also establish requirements similar to those in place for transport pilots regarding licenses and training, as specified in JAR-OPS subparts N and O.

The requirements for engaging in SAR operations in Spain are imposed through the conditions defined in SASEMAR's contract specifications. These requirements should include the aspects considered in this analysis. SASEMAR should also increase its oversight and control of the way in which the operator provides the SAR service. Safety recommendations are issued in this regard.

3. CONCLUSION

3.1. Findings

Use of the SAR APPROACH list

- The full list was not completed on any of the approaches.
- The completion percentage of the list ranged from 9% to 85%.
- On four of the five lists, memory items were done in an order different from that specified on the list and some memory items were not done.
- All 15 items on the list were only completed, and in order, on one of the approaches.
- The completion of the list was never announced.

Use of SAR DEPARTURE list

- The full list was not completed on any of the departures.
- The completion percentage of the list ranged from 0% to 17%.
- The list was not read on any of the departures.
- The start and completion of the list was not announced.

Use of other lists

- The CLIMB/CRUISE/DESCEND checklists were not performed.
- The only list requested was the BEFORE LANDING list.
- With regard to the approach to hover and hover phases, the departures were the most informal in terms of the application of lists and crosschecks.

SAR Maneuvers

- The rescue maneuvers per se were prioritized and executed rigorously, with the rest of the flight being given less importance.
- All of the approaches to hover were done in manual. None of the SAR modes was used.
- The approaches did not conform to the requirements in the manual and the lists, with the altitudes, speeds and distances being different from those specified.
- All of the checks and call-outs specified in the SAR SOM were done during winch operations.
- The departures were done in manual and using the Transition Up SAR mode.
- Transmissions were made to the vessels before the departures were complete.
- At no time during the flight did the decision heights selected correspond to those specified in the lists.

Impact

- The helicopter impacted the water while in controlled flight.
- The impact was unexpected by the crew. No evasive maneuvers were taken.
- The aircraft impacted in level flight under power at a GS of 110 kt.
- The captain made deliberate control inputs to lose altitude and increase speed.
- The captain misjudged their altitude throughout the entire descent, believing it to be higher than it actually was.
- The copilot was busy with radio communications and with the BEFORE LANDING list and did not check any of the instruments.
- After departing from the hover, the captain stopped the climb via inputs to the flight controls.
- Torque dropped from 83% to 30% at the time of impact via inputs made to the collective FTR to decrease the collective.
- The transition from climb to descent was gradual and not noticed by the rest of the crew.
- The LANDING GEAR and ONE FIFTY FEET warnings sounded during the final six seconds and were acknowledged by the captain.
- The CHECK HEIGHT warning associated with the DHs set did not have time to sound due to the descent rate.
- The LANDING GEAR and ONE FIFTY FEET warnings sounded twelve times each during the flight.
- The crew did not take any evasive actions in response to the warnings prior to impact.
- Meteorological conditions did not have any effect on the accident.
- There were no problems associated with the fuselage or engines.
- The fuel remaining and its quality were not a factor in the accident.
- There were no problems involving erroneous information displayed to the crew by the instruments.
- The last departure involved transitioning from very demanding tasks over the course of a two-hour flight to one less demanding under low light conditions (use of spotlight).

Crew

- The crew had valid licenses and medical certificates at the time of the accident.
- The mood in the cockpit was one of cordiality and mutual respect.
- All of the crew members were highly motivated to achieve the maximum training benefit from the flight. The crew had very high expectations from the flight.
- As a result of the copilot's inexperience, the roles of the flight crew were those of instructor-student, not of captain-copilot.
- The captain was overtasked by his dual role as captain and instructor.
- The captain supervised and instructed both the copilot's actions and his communications.

- The cockpit workload was unevenly distributed, with the captain performing not only his duties but many of the copilot's.
- Many of the copilot's actions performed by the captain were not communicated and led to confusion on the part of the copilot.
- The copilot exhibited problems with some basic flight skills.
- The copilot was "out of the loop" on three occasions: ten, five and two minutes before the accident.
- The copilot had problems with the use of Spanish, especially during radio communications.
- The flight crew had problems with the maritime aspects of the operations.
- The flight crew exhibited conceptual errors regarding the decision height, using this term to refer to other concepts.
- Colloquial terms and translations from English to Spanish were used to refer to checkpoints in the procedures.
- The pilots had undergone very little flight hours in the last three months: 25 and 23 h.
- The captain had considerable experience on helicopters, adequate experience on the AW139 and very little in nighttime SAR.
- The copilot had very little experience in the AW139 helicopter, in SAR, nighttime SAR and IFR.

Helicopter

- The helicopter had all the required permits for the activity for which it was being used.
- The distress radiobeacon did not work.
- The copilot's display was not working, a condition that is not allowed by the Flight Rotor Manual and by the MMEL for nighttime flights.
- The helicopter had a deferred item that should have been closed out by 14 December 2009. Operations with this deferred item were not allowed by the MMEL.
- One of the deferred items involved the operation of the DH aural warning. This discrepancy, which had existed for two months, did not reflect the actual condition of the helicopter since the warning was functional.
- There were not a minimum equipment list (MEL) and a minimum equipment requirements adapted to the requirements of SAR operations.

Operator's documentation

- At the time of the accident, there were no procedures or SAR checklists specific to the AW139.
- The SAR procedures that the crew was using did not consider the use of the technical aids available in the helicopter and were not adapted to the helicopter's technical capabilities.

- The versions in the bases, the operations office and the owner were all different. Versions from the same date had different contents.
- The name of the operator, INAER HELICÓPTEROS OFF-SHORE, did not appear in the manuals, being shown instead as INAER or HELICSA.
- There were serious discrepancies among different parts of the SAR SOM and between the SAR SOM and the lists, both in their layout and contents. These discrepancies show that the SAR SOM was not designed or adapted to reflect the reality of SAR operations.
- The contents of the SAR ground course did not match those of the SAR SOM and contained information on procedures that did not exist.
- The hiring process relied on the CV and on a personal interview.
- Due to the nature of SAR missions, which is to save lives, there was a culture of urgency and to perform the mission under any circumstances. This culture extended to other situations, such as training flights.
- A single-pilot rating was required due to the certification of the helicopter. SAR operations require a multi-pilot crew due to the high workload and risk involved.
- There was no training on CRM, MCC, ALAR, CFIT or fatigue, nor was such training required by regulations.
- There was no SAR risk management assessment or a specific safety management system for SAR activities, nor were they required by regulations.

Design of the SAR lists used by the crew

- The SAR lists used by the crew were not tailored to the helicopter's technical capabilities.
- There were inconsistencies between the various checklist versions.
- The revision used by the crew was two versions older than the one in effect, although the contents were the same.
- The lists were in English and had call-outs in English that were translated into Spanish during operations.
- The terminology used to refer to the same concept in the SAR SOM, checklists and actual operations differed: prelanding-pretoma-before landing, three green-3 UP, sea approach-approach to hover, door closed and latched-cabin clear.
- The SAR APPROACH list had 21 items and included three verification parts, meaning it had to be interrupted three times during execution. The parts were not differentiated and were all in the same color, except for the final item (checklist complete).
- The SAR DEPARTURE list had 18 items and included HOVER, pre-departure and departure segments, with the departure always being performed in manual.
- The SAR DEPARTURE list required disengaging the FD before departure, which precluded the use of fly-up mode, which is one of the aids against a loss of altitude.
- The SAR DEPARTURE list did not specify setting the DH for the new phase of flight, though the SAR SOM specified it at 200 ft.

Regulator

- There are no regulations in Spain specific to SAR operations.
- The only requirements placed on air operators are those specified by SASEMAR as part of its contracting conditions.

3.2. Causes

The accident of helicopter EC-KYR is consistent with a controlled flight into water caused by:

- The captain's misjudgment of their altitude due to the vertical illusion resulting from the use of external references, due to a faulty interpretation of the instrument readings or to a combination of both.
- The copilot's failure to monitor the flight parameters.

The following factors contributed to the accident:

1. Possible crew fatigue produced by:
 - The demands of SAR operations.
 - The captain's excessive workload, resulting from taking on not only his duties and responsibilities but many of the copilot's.
 - The excessive cognitive effort made by the copilot due to his relative inexperience with SAR and to the effort required for him to understand and communicate in a language that was not his native tongue.
2. A shortage of crew training in SAR operations and CRM that:
 - Hampered the captain's handling of the unresolved conflict between giving the copilot more autonomy while fully confiding in his flying skills.
 - Prevented the copilot from being sufficiently assertive to communicate his difficulty in staying abreast of the flight due to the captain's unreported actions and his desire to complete the flight successfully with a captain who was very much his senior.
 - Impeded the captain and copilot from identifying and managing their fatigue.
 - Impeded the crew's handling of the transition between a highly demanding activity (SAR exercises) and a routine activity (return flight).
 - Resulted in the crew's constant exposure and habituation to the LANDING GEAR and ONE FIFTY FEET audio warnings, which made these warnings ineffective in preventing the impact.
3. The definition and inappropriate use of SAR checklists not adapted to the helicopter model and to SAR operations, and which included disengaging the Flight Director.
4. The lack of regulations specific to SAR operations in Spain, and the low requirements placed on the operator by the SAR service provider.

4. SAFETY RECOMMENDATIONS

Safety recommendations addressed to AESA

- REC 21/12.** It is recommended that AESA, as one of the bodies designated by Spain as its civil aviation authority, start developing specific regulations suited to SAR operations in Spain.
- REC 22/12.** It is recommended that AESA, as one of the bodies designated by Spain as its civil aviation authority, require a multi-pilot training for conducting SAR operations.
- REC 23/12.** It is recommended that AESA, as one of the bodies designated by Spain as its civil aviation authority, require a minimum equipment requirements specifically for SAR operations for those companies wishing to engage in this type of activity.
- REC 24/12.** It is recommended that AESA, as one of the bodies designated by Spain as its civil aviation authority, as part of the regulations devised for SAR operations, require the implementation of a safety management system (SMS) for SAR service providers and for air operators who wish to engage in SAR operations that, at a minimum:
- Identifies operational safety risks.
 - Ensures that the necessary corrective measures are applied to maintain operational safety.
 - Requires permanent oversight and the periodic evaluation of operational safety.
 - Sets a goal of constant improvement in overall SMS performance.

Safety recommendations addressed to SASEMAR:

- REC 25/12.** It is recommended that SASEMAR, as the responsible of SAR services, place requirements in its contracts with those companies wishing to engage in SAR operations that consider, at a minimum, the aspects included in this report and the safety recommendations issued herein.
- REC 26/12.** It is recommended that SASEMAR, as the responsible of SAR services, take the measures necessary to increase the oversight and monitoring of the conditions under which SAR services are provided, considering, at a minimum, the aspects included in this report and the safety recommendations addressed to INAER HELICÓPTEROS OFF-SHORE.

REC 27/12. It is recommended that SASEMAR, as the responsible of SAR services, take the measures necessary to increase the number of hours dedicated to training exercises to suit the risks and hazards involved with SAR operations.

Safety recommendations addressed to INAER HELICÓPTEROS OFF-SHORE

REC 28/12. It is recommended that INAER HELICÓPTEROS OFF-SHORE, as the SAR operator, review, complete, modify, standardize and adapt its Search and Rescue Special Operations Manual (SAR SOM) to have it reflect the reality of SAR operations.

REC 29/12. It is recommended that INAER HELICÓPTEROS OFF-SHORE, as the SAR operator, write procedures and checklists specific to operations with the AW139 helicopter. The lists should employ terminology that is understandable for all crews and avoids the need to translate from English to Spanish. The lists should comply with design criteria for preparing checklists.

REC 30/12. It is recommended that INAER HELICÓPTEROS OFF-SHORE, as the SAR operator, improve the skills of its crews so that they use all of a helicopter's technical capabilities on SAR operations, such as:

- The fly-up function associated with the collective's FD modes.
- The decision heights.
- The SAR modes.
- The selection of suitable working altitudes so that the aural warnings associated with 150 ft have the desired alerting effect when is really needed.

REC 31/12. It is recommended that INAER HELICÓPTEROS OFF-SHORE, as the SAR operator, modify its training schedule to have shorter but more frequent exercises to ensure that the same number of hours yield more frequent training.

REC 32/12. It is recommended that INAER HELICÓPTEROS OFF-SHORE, as the SAR operator, provide or enhance, as the case may be, its:

- CRM training.
- MCC training on a simulator.
- Training on spatial disorientation.
- Training on maritime terminology.

REC 33/12. It is recommended that INAER HELICÓPTEROS OFF-SHORE, as the SAR operator, enhance its crew training so that “rescue” maneuvers are given the same importance and executed with the same rigor as the rest of the “flight”. Changes should be made to the way in which the following tasks are executed and prioritized:

- Flight and rescue maneuvers: giving the same importance to both and executing them completely and in rigorous compliance with procedures.
- Checklists: clearly identifying the list, its start and completion, checking every item on the list and using standard terminology that allows all crews to apply the procedures uniformly.
- Non-flight tasks (such as communications with ATC or with vessels) during critical phases of flight such as SAR approaches and departures.

REC 34/12. It is recommended that INAER HELICÓPTEROS OFF-SHORE, as the SAR operator, draft a minimum equipment requirements specifically for SAR operations.

REC 35/12. It is recommended that INAER HELICÓPTEROS OFF-SHORE, as the SAR operator:

- Modify its system for tracking deferred items to ensure that said items reflect the actual condition of the aircraft.
- Establish measures to reduce the length of time items are deferred.
- Train its maintenance and flight personnel to ensure the MMEL is applied correctly and that operations are not made in conditions not allowed by the MMEL and by the Flight Manual.

REC 36/12. It is recommended that INAER HELICÓPTEROS OFF-SHORE, as the SAR operator, standardize communications between helicopters and the base, identifying who is to establish contact, with what means and at what phase of the operation so as not to interfere with the critical phases of flight.

Safety recommendations addressed to the EASA

REC 37/12. It is recommended that the EASA, as the certifying authority, review the proof of compliance involved with the certification standards for the HR Smith 503 emergency locator transmitters installed on the AgustaWestland AW139 helicopter.

