AAIB Bulletin No: 5/2005 **Ref: EW/C2004/09/03** **Category: 2.1**

Aircraft Type and Registration:	Sikorsky S-61N, G-BDOC
No & Type of Engines:	2 General Electric CT58-140-2 turboshaft engines
Year of Manufacture:	1976
Date & Time (UTC):	15 September 2004 at 0800 hrs
Location:	Near Sullom Voe, Shetland
Type of Flight:	Commercial Air Transport
Persons on Board:	Crew - 4 Passengers - 1
Injuries:	Crew - None Passengers - None
Nature of Damage:	Four main rotor blades damaged
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	37 years
Commander's Flying Experience:	6,905 hours (of which 4,100 were on type) Last 90 days - 49 hours Last 28 days - 10 hours
Information Source:	AAIB Field Investigation

Synopsis

During a winching operation, the rotors of G-BDOC struck the top of a mast on the deck of the receiving ship. The helicopter recovered safely to Scatsta Aerodrome. The investigation revealed some misunderstandings between the helicopter operator and the maritime operator about the winching deck markings on the ship. Accordingly, recommendations have been made to the CAA and to The International Chamber of Shipping (ICS) to ensure that aircraft and ship crews are aware of the information required before undertaking winching operations. Shortly after the accident, the helicopter operator instituted revised rules to clarify the information required before any winching operation.

History of flight

The crew, consisting of the commander, first officer, winch operator and winchman, had been on SAR duties at Sumburgh Airport since 1200 hrs on 14 September. That evening, a Commercial Air Transport (CAT) tasking was received to transfer marine pilots to and from ships near Sullom Voe on the morning of 15 September.

The next morning, the crew were informed of the timing of the task and lifted-off from Sumburgh Airport at 0715 hrs to fly to Scatsta Aerodrome to collect the first marine pilot. By 0800 hrs, the marine pilot had been uplifted and G-BDOC set course for the designated ship, which was located some 15 nm north of Scatsta. On departure from Scatsta, the weather was as follows: Surface wind 340°/18 kt; visibility greater than 10 km; light rain; cloud FEW at 1,400 feet amsl and SCT at 2,400 feet amsl; temperature +05°C; QNH 1017 mb. The commander subsequently confirmed that the helicopter had been fully serviceable during the flight to the ship.

From the transit altitude of 300 feet amsl, the crew visually acquired the ship and, having established communication on FM radio, identified the winching area; this was indicated by a solid yellow circle surrounded by a broken yellow circle (Figure 1). Having completed the standard pre-winching checks and an engine power check, the helicopter was positioned on the port side of the ship. The ship was heading north at approximately 8 kt and the commander, who was the handling pilot in the right cockpit seat, assessed the surface wind as northerly 25 kt gusting to 30 kt. There was no significant cloud in the area and no turbulence. The first officer in the left cockpit seat was operating VHF communications with Scatsta and the winch operator, positioned in the opening of the cargo door on the right side, was operating FM communications with the ship.

In position, the crew reviewed the designated winching area and considered that there would be a possible obstruction (mast) to the rear of the helicopter when in the winching position. Accordingly, the crew agreed that they would move their intended winching position forward some 40 feet to an area marked by a green walkway. This new area was assessed to be clear although the crew was aware of a yellow-topped mast riser located on the deck and to the right of G-BDOC. In the new winching position, this mast would be in the commander's four o'clock position; from the open cargo door, the winch operator would be monitoring the relative position of the mast.

The commander then manoeuvred the helicopter over the new winching position and established a hover at approximately 40 feet above the deck. After a further power check, and with good visual references, the crew agreed that the position was suitable for winching operations. The commander then descended to approximately 20 feet above the deck. He noted that there was a slight 'heave' and 'roll' on the ship but assessed the conditions as suitable. As the commander held G-BDOC in position the winchman was lowered to the deck where he released himself in preparation for receiving the marine pilot. With the winch operator 'looking in' to prepare the marine pilot for winching, the commander considered that he was maintaining his position over the deck. The first officer was monitoring the situation and also considered that the commander was holding a steady hover, albeit that the ship was rolling slowly. Shortly after, the commander became aware that the helicopter had drifted slightly forward and to the right. As he began to correct for this, the winch operator also called for a movement back and to the left. Then, with the desired position re-

established, the winch operator started to lower the marine pilot. Shortly after, the commander heard a short repetitive noise and he immediately moved the helicopter slightly higher and to the left. His impression was that the event was similar to a 'birdstrike' that he had previously experienced. The first officer was also aware of a vibration through the airframe and heard the winchman on the deck calling on FM that there had been a possible "*Blade strike*". The winch operator was aware of the crew comments but had seen or heard nothing else to confirm any such event. From the new position, some 6 feet to the left and some 10 to 20 feet higher, the commander reviewed the situation. The controls appeared normal and, with no vibration and no other abnormal indications, the commander followed the winch operator's guidance back to the original winch position but maintained the new height (some 30 to 40 feet above the deck). The marine pilot was then lowered to the deck and the winchman was winched back on board G-BDOC.

The winchman had not been confident that his original message had been heard and immediately informed the crew that there had been a blade strike. On the deck when he was facing to the rear of the ship, he had heard a loud noise to his left when the marine pilot had been some 6 feet above him. At the time, he looked to his left and saw that the rotors were very close to the mast riser.

With all the crew back on G-BDOC, the commander manoeuvred the helicopter to the left, clear of the ship and carried out an uneventful control check. He then slowly increased height and speed before making a gentle turn directly for the land nearest Scatsta Aerodrome. A 'PAN' call was transmitted to Scatsta. During the transit, there was no apparent vibration in the cockpit or cabin and a visual observation of the blade tip movement indicated no abnormality. Additionally, there was no indication of any defect from the Health and Usage Monitoring System (HUMS) or from the Blade Integrity Monitoring (BIM) system. Once over land, the commander headed directly for Scatsta and landed into wind on the intersection of the runway and taxiway.

Engineering information

Following the landing at Scatsta, the helicopter was examined for damage. Four of the five main rotor blades had extensive damage on the lower surface of the blade, starting at about 25 cm from the blade tip. Examination of the top of the yellow mast riser on the tanker showed corresponding damage to the vent, including the loss of a substantial lifting lug welded to the upper edge.

All five blades were removed from the helicopter, which was subjected to a thorough inspection. There was no evidence found of other damage and the aircraft was returned to service with replacement main rotor blades

Figure 2 shows the damage to the lower surface of the Red blade. This blade showed evidence of two strikes, with the inboard marking at about 25 cm from the tip and the outboard mark at about

10 cm from the tip. The damage was similar to the Blue blade, with both blades having suffered extensive gouging of the main rotor spar and disruption of the bonded blade skin. The Black and Yellow blades had similar inboard damage but no outboard strike and there had been no visible contact with the White blade. None of the blade spars had been fully penetrated so the BIM system, which operates on pressure release, would not have been activated.

A review of the maintenance records for G-BDOC by the AAIB showed no indication of the condition of the aircraft being a factor in this accident.

Deck dimensions and clearances

Figure 1 shows a photograph of the tanker berthed at Sullom Voe following the accident, with the shadow of another S-61N at the winching circle. The following ship dimensions are derived from a general arrangement drawing from the tanker management company and the manufacturer's dimensions for the S-61N.

The drawing shows the diameter of the manoeuvring zone as 27 metres (radius 13.5 metres) and the winching circle as five metres. The distance from the edge of the manoeuvring zone to the obstruction to the rear was 11 metres, compared with 5.5 metres to the yellow-topped mast riser obstruction. Thus the nearer obstruction from the winching circle was the mast riser, which had a height over the tanker deck of 10 metres. The radius of the S-61N main rotor is 9.45 metres and so, with the main rotor over the centre of the winching circle, the average clearance of the main rotor disc from the mast riser would have been approximately 9.6 metres. In the same position, the average clearance of the tail rotor disc from the obstruction to the rear would have been approximately 11.8 metres.

The precise position of the helicopter's new winching position relative to the green walkway is not known. However, positioned with the centre of the main rotor directly forward of the winching circle and over the centre of the walkway, the average clearance of the main rotor disc from the mast riser would have been approximately 2.1 metres.

The roll of the ship was not significant to the crew and has been estimated as 3°. With the top of the mast riser approximately 18 metres above the ship's centre of gravity, the total arc of the top of the mast riser would be approximately two metres, bringing it very close to the main rotor disc.

Recorded information

The helicopter carried a combined CVFDR recorder. This provided 60 minutes of CVR, 5 hours of FDR and health monitoring recordings. The quality of the recordings was good.

The CVR confirmed the recollection of the crew as detailed in the History of Flight section. The only additional information yielded by the CVR relates to the analysis of the noise during the blade strike. This would indicate that the blades struck with unequal audible effect and at least one blade struck a second time.

Figure 3 shows relevant FDR parameters together with related crew activities. Given a lack of data pertaining to the ship's movements, the FDR data could not be used to reconstruct the motion of the helicopter relative to the ship except that the radio altitude shows when the helicopter was over the deck of the ship. The radio altitude also indicated that the peak-to-peak wave effect at the time was about five feet. The radio altitude above the deck started at 55 feet and settled to approximately 20 feet after about a minute, holding steady at 20 feet plus/minus wave action for a further minute and a quarter before the blade strike. After the blade strike, the helicopter altitude increased to approximately 45 feet above the deck. Over the next 40 seconds, the helicopter remained over the deck with a slow reduction of mean radio altitude of about five feet. Some 45 seconds after the blade strike, the helicopter was over water.

The health monitoring data only sampled the blade tracking once after the event. This showed a marked change in blade tracking but the track split was within acceptable limits.

Crew information

Interviews with the crew confirmed the following information:

1. During winching, the winch operator was monitoring the yellow-topped mast and considered that it was clear of the rotor disc but he was aware that the top of it was above the disc.

2. The winchman remained in the same position during his time on the deck.

3. The marine pilot could not identify his exact position over the deck whilst being winched down, but he considered that the winchman was directly below him.

Aviation regulations

Civil Air Publication (CAP) 437 (issued Sep 2002) contains guidance for helicopters landing or winching on offshore areas. This includes information on winching areas and states that a winching area should provide a 'manoeuvring zone' with a minimum diameter of 2D (D being the overall length, with rotors turning, of the largest helicopter able to use the area) and marked by a yellow 0.2 metre wide broken line. Within the 'manoeuvring zone' a yellow painted clear area (five metres in diameter) should be centred. Near the clear area, the words WINCH ONLY should be marked in white so as to be clearly visible to the helicopter pilot. Within the inner 1.5D diameter of the 'manoeuvring zone', outside the clear area, there should be no objects higher than 3 metres. In the outer 0.5D diameter, there should be no objects higher than 6 metres. (Note: 'For the S-61N helicopter, D is defined within CAP 437 as 22.2 metres.')

For Commercial Air Transport (CAT) operations, the helicopter company had received written dispensation from the CAA *'from the provisions of Rule 5(1) (e) of the Rules of the Air Regulations 1996, so as to permit the said helicopter to fly within 500 feet of any person, vessel, vehicle or structure' when it is being used for the purpose of picking up, raising or lowering persons or articles to or from a site which:*

1) *Is at least 10 feet square*
2) *Provides a level, non-slip surface free from spray, and*
3) *Provides at least 20 feet horizontal rotor clearance at all hover heights.'*

The company Operations Manual detailed the procedures for CAT winch operations. Relevant extracts were as follows:

1. *'The commander must ensure that the manoeuvring area satisfies the requirements laid down in the exemption held on the operation.*
2. *During a transfer, the winch operator is responsible for providing guidance to enable the pilot to position the helicopter accurately and clear of obstructions.*
3. *The winch operator must endeavour to maintain the passenger at a height no greater than 40 feet above the sea or 10 feet above the deck'*

Maritime regulations

The International Chamber of Shipping (ICS) has published a 'Guide to Helicopter/Ship Operations' (latest edition published in 1989), which comprehensively describes physical criteria and procedures on ships. This includes the same information on 'manoeuvring zones' described in CAP 437. The publication also includes comprehensive guidance on communications between 'Master', 'Agent' and

'Helicopter Operator' and between 'Helicopter' and 'Ship'. This includes guidance to 'Masters' that information on the size of the manoeuvring zone should be passed to the 'Agent' at least 24 hours before the anticipated operation. The publication also includes guidance on the information to be passed by the 'Agent' to the 'Helicopter Operator' and this includes the dimensions of the Clear/ Manoeuvring Zone. Additionally, the guidance for the communications between the 'Ship' and 'Helicopter' includes confirmation of the dimensions of the Clear and the Manoeuvring Zones. The Guide also includes information on the D values of commercial helicopters in marine use and this shows the S-61N with a D value of 22.3 metres (slightly different from CAP 437). It also emphasises that: *'It is essential that the type and overall length of a helicopter are known before it is accepted by the ship.'*

The ship involved in the accident, which was non-UK registered, held a copy of the '*Guide to Helicopter/Ship Operations*' as required by the ship's manager. The master of the ship involved provided information on dimensions, obstructions and markings related to the winching area. This included the following:

1. The clear area was marked with a yellow painted five metre diameter circle, which was located 6.5 metres inboard of the port shipside.
2. The 'manoeuvring zone' had a diameter of 27 metres and was marked by a yellow 0.2 metre wide broken line.
3. WINCH ONLY was marked in white alongside the clear area.

Subsequent actions

Five days after the accident the helicopter company circulated the following instruction to their crews:

> *'As a result of a recent air accident during CAT winch operations, the following additional requirements are effective immediately.*
>
> *Before accepting a CAT winching task, the aircraft commander shall obtain the following information from the vessel:*
>
> *1) The location of the intended winching area.*
>
> *2) The diameter (in feet or metres) of any "manoeuvring zone" marking.*
>
> *3) The distance, from the centre of the winching 5 metre "clear zone", of the nearest obstruction higher than 5 metres together with its height above deck level.*

This information shall be included in the pre-departure crew briefing and shall be used in deciding the planned minimum winching height. The Operations Manual guidance that the winch operator must endeavour to keep the passenger at a height no greater than 10 ft above the deck (OM Pt A. CAT Winch Operations Supplement, para. 7f) may be disregarded as long as persons being raised or lowered are kept at the lowest height commensurate with safe operations. The Operations Manual will be amended.'

The management organisation for the ship involved in this accident has taken the following actions after a review of their operations:

1) *Ships Masters have been instructed to ensure a proper exchange of information with the helicopter operator regarding the vessel's marking, and specifically to include the diameter of the winching area.*

2) *Albeit that the current markings are valid they are now studying, and considering changing, the markings in order to facilitate the reception of larger helicopters if feasible.*

Discussion

The accident occurred during a winching operation involving a very experienced crew. The crew assessed the situation prior to winching but their decision to move the winching area resulted in a reduced safety margin. It was not possible to determine whether the strike occurred due to movement of the ship or to the movement of the helicopter. The investigation revealed that the winching instructions for crews were not sufficiently comprehensive. Furthermore, the winch markings on the ship did not comply with the '*Guide to Helicopter/ Ship Operations*' for winching involving an S-61N helicopter. Therefore, this discussion considers both helicopter and ship aspects with a view to reducing the possibility of a similar event in the future.

The helicopter crew were primarily on SAR duties. This could involve winching a casualty from any sea vessel and, in order to save lives, the crew would need to assess the situation and make appropriate decisions once they were positioned close to the vessel. However, any pre-planned winching of an individual to or from a vessel is a Commercial Air Transport operation. When undertaking CAT duties, there is a clear responsibility for the helicopter operator and the commander to have sufficient information prior to flight to ensure that the operation can be safely conducted using the relevant regulations. One of the contributing factors of this accident may have been that the crew moved temporarily from SAR duties, where flexibility is required, to the more structured environment associated with CAT duties. While the commander has overall responsibility for ensuring the safety of any operation, when undertaking CAT duties he is reliant on the provision of full information and effective regulation.

Recommendations

Immediately following the accident the helicopter operating company recognised the limitations of their extant regulations and issued amended instructions to all crews. This emphasised the essential requirement for the commander to obtain all essential information from the appropriate vessel for any CAT winching task. However, other similar companies also have crews operating primarily on SAR duties but being given CAT tasks. Therefore, the AAIB has issued the following safety recommendation:

Safety Recommendation 2005-027

The Civil Aviation Authority should establish clear guidance for companies operating both Search and Rescue (SAR) tasks and Commercial Air Transport (CAT) tasks to ensure that current and future operators have clear regulations for crews involved in both types of task during one period of duty.

The guidance material for ships is comprehensive but its usefulness is obviously dependent on availability, accuracy and compliance. Although the document was available, the deck markings did not comply with the '*Guide to Helicopter/ Ship Operations*' for a helicopter of the size of an S-61N. However, while the guidance is useful, it remains of paramount importance for the crews of the helicopter and ship to have and exchange essential information. Both crews should be aware of the type of helicopter involved and the dimensions of the deck markings. During the investigation, it was noted that for helicopter landing areas on board ships, the D value is required to be displayed at the perimeter of the deck. An indication on a winch 'manoeuvring zone' of the D value or even the actual diameter of the 'zone' would reduce the amount of necessary communication between the ship and helicopter crews. However, any such indication would be dependent on the accuracy of the declared dimensions. At present, there is a confliction between the D values for the S-61N in CAP 437 and in the '*Guide to Helicopter/ Ship Operations*'. Accordingly, it would be appropriate for the relevant maritime organisation to review the guidance provided for ship masters and to encourage the carriage of such guidance on board relevant ships. Therefore, the AAIB has issued the following safety recommendations:

Safety Recommendation 2005-028

The International Chamber of Shipping should review the current '*Guide to Helicopter/ Ship Operations*' to ensure that it is accurate and includes information on all current helicopters.

Safety Recommendation 2005-029

The International Chamber of Shipping should encourage the practice of holding a current copy of the '*Guide to Helicopter/ Ship Operations*' by all ships that may be involved in helicopter operations.

Safety Recommendation 2005-030

The International Chamber of Shipping should review the deck markings on ships involved in winching operations with the aim of including a requirement to clearly display the dimensions of the 'manoeuvring zone', such that it can be clearly seen by the helicopter crew.

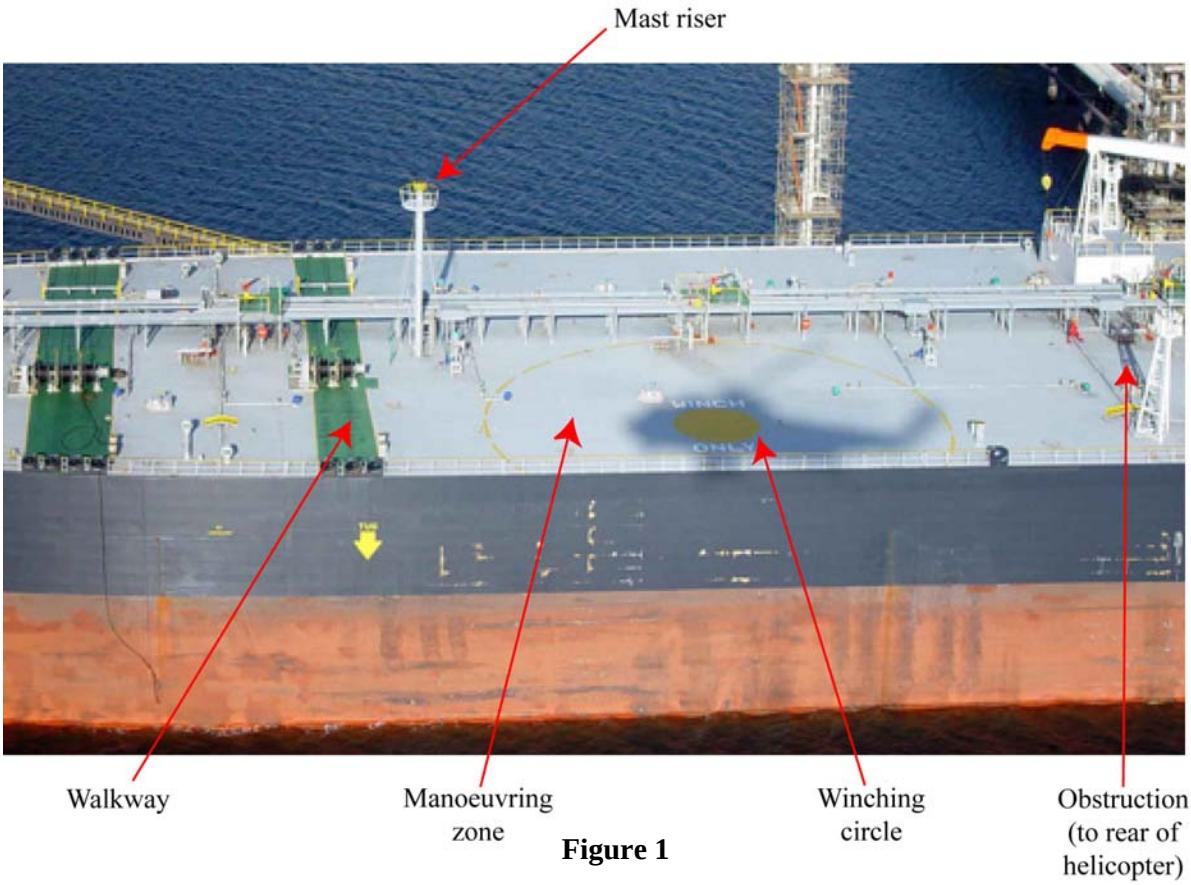

Figure 1

Tanker deck

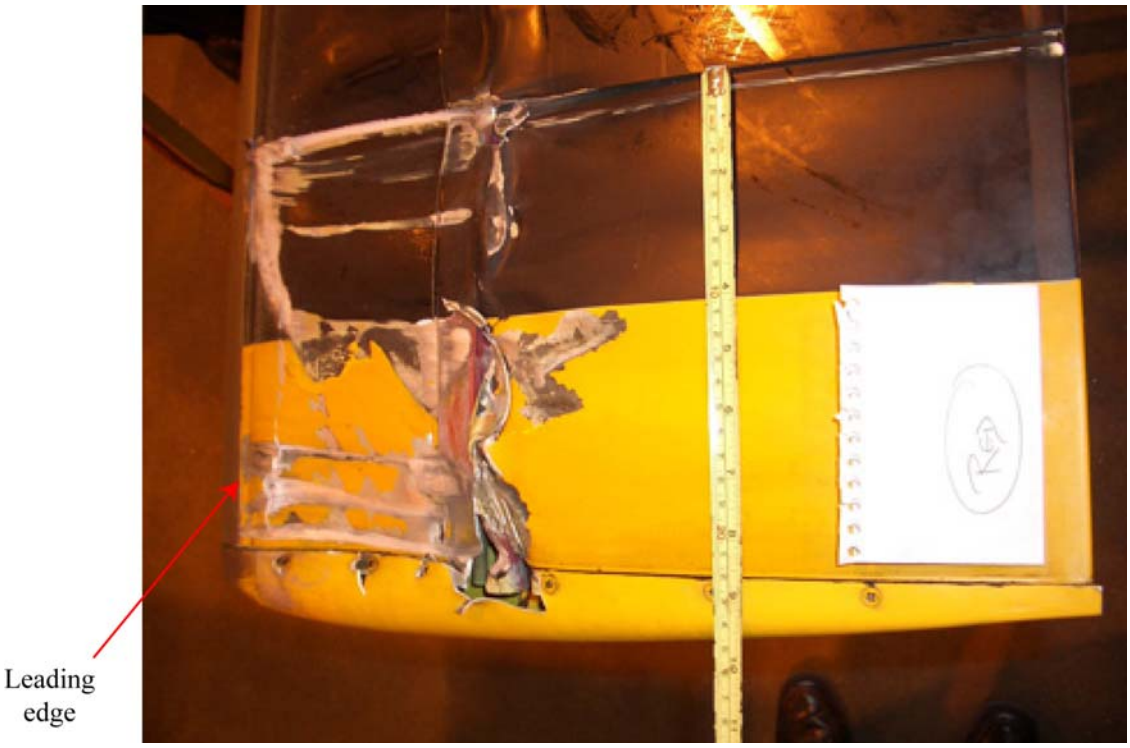

Figure 2

Red blade - lower surface

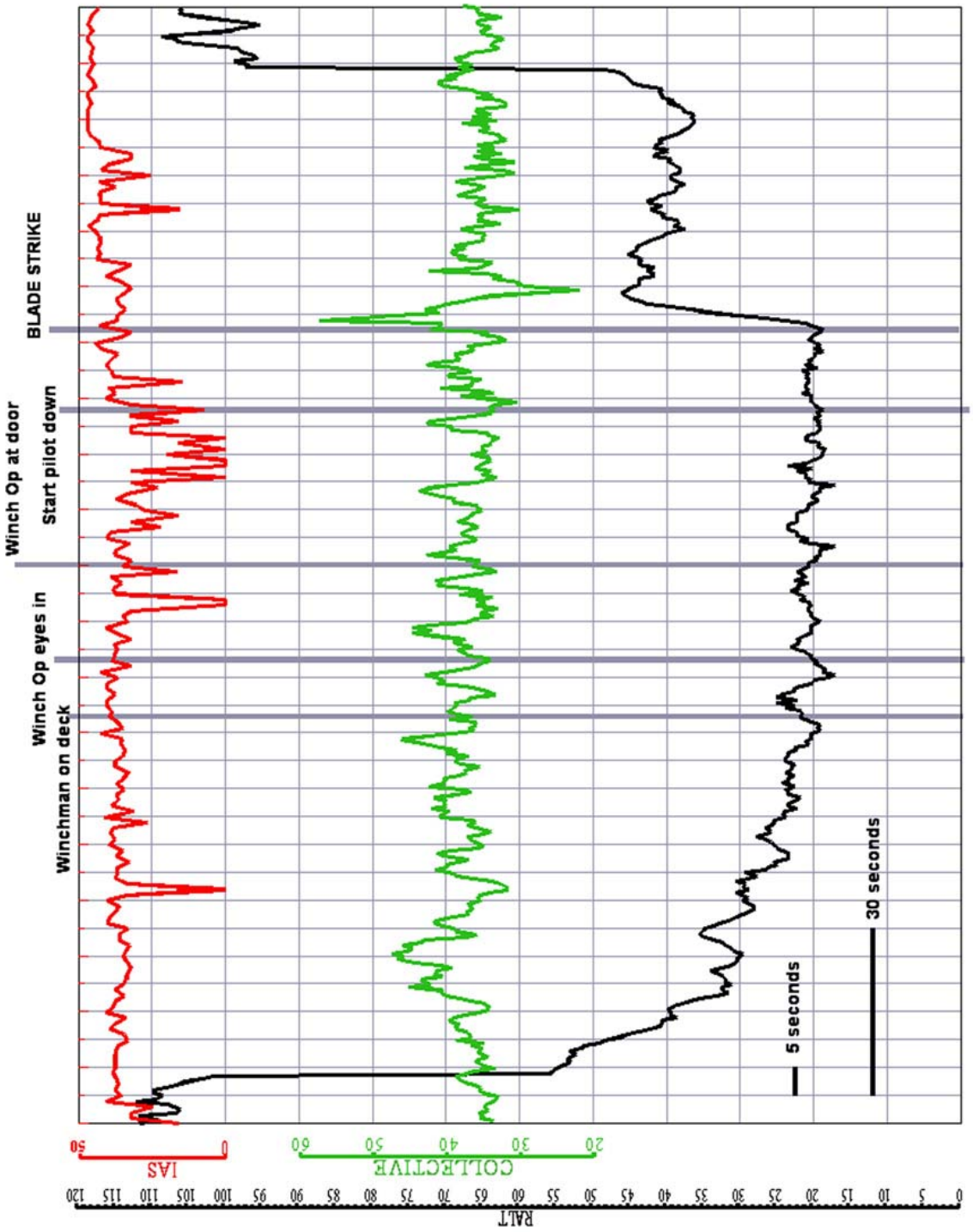

Figure 3
Relevant FDR parameters and related crew activities